APRIL 26, 2021 / #NGINX

# The NGINX Handbook

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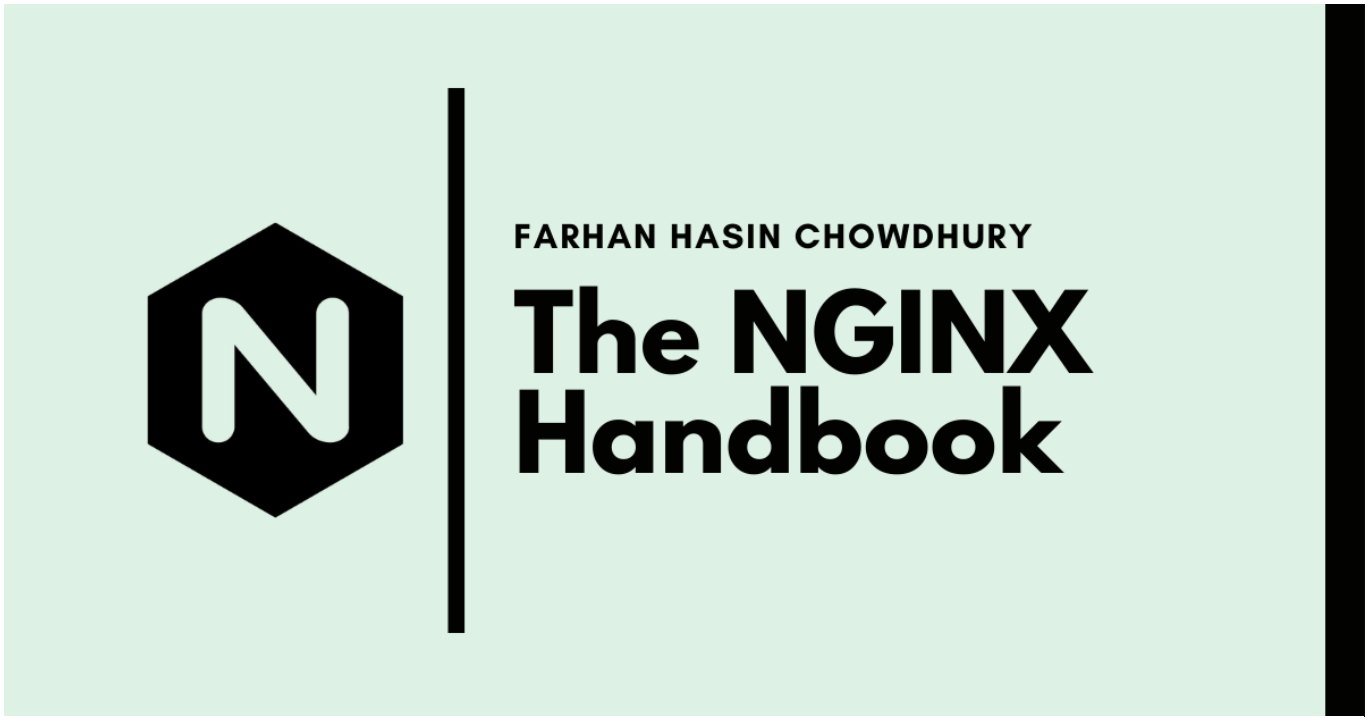


A young Russian developer named Igor Sysoev was frustrated by older web servers' inability to handle more than 10 thousand concurrent requests. This is a problem referred to as the C10k problem. As an answer to this, he started working on a new web server back in 2002.

NGINX was first released to the public in 2004 under the terms of the

Thanks to tools like NGINXConfig by DigitalOcean and an abundance of pre-written configuration files on the internet, people tend to do a lot of copy-pasting instead of trying to understand when it comes to configuring NGINX.


Trust me, it's not that hard...

I'm not saying that copying code is bad, but copying code without understanding is a big "no no"

according to the requirements of the application to be served and available resources on the host.

That's why instead of copying blindly, you should understand and then fine tune what you're copying – and that's where this handbook comes in.

After going through the entire book, you should be able to:

- Understand configuration files generated by popular tools as well as those found in various documentation.
- Configure NGINX as a web server, a reverse proxy server, and a load balancer from scratch.
- Optimize NGINX to get maximum performance out of your server.

# Prerequisites

- Familiarity with the Linux terminal and common Unix programs such as `ls`, `cat`, `ps`, `grep`, `find`, `nproc`, `ulimit` and `nano`.
- A computer powerful enough to run a virtual machine or a $5 virtual private server.
- Understanding of web applications and a programming language such as JavaScript or PHP.

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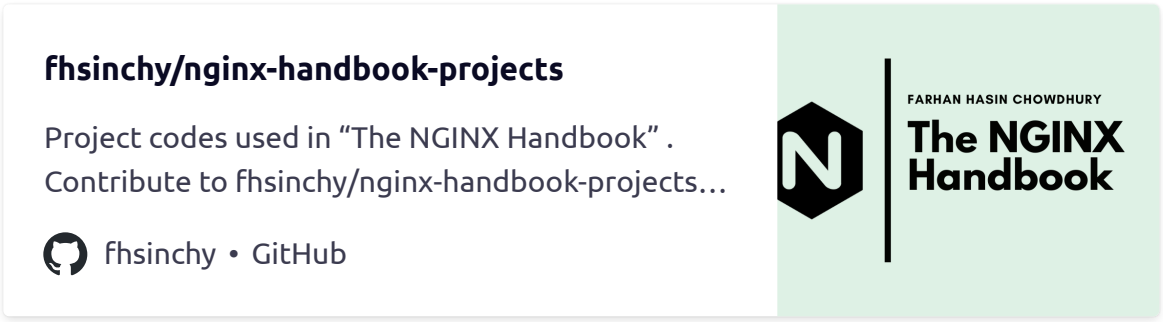
# Project Code

You can find the code for the example projects in the following repository:




spare a ⭐ to keep me motivated

The `master` branch holds all the code used in this book.

# Introduction to NGINX

NGINX is a high performance web server developed to facilitate the

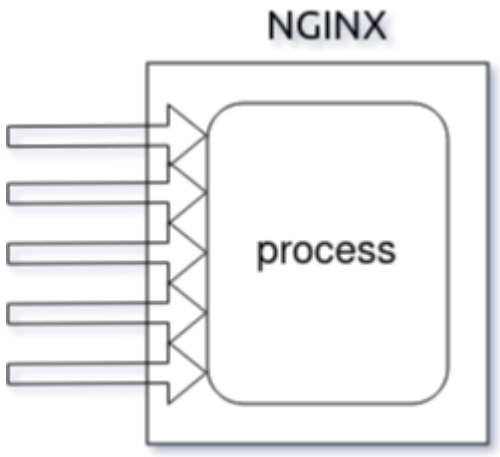
NGINX is not the only web server on the market, though. One of its biggest competitors is Apache HTTP Server (httpd), first released back on 1995. In spite of the fact that Apache HTTP Server is more flexible, server admins often prefer NGINX for two main reasons:

- It can handle a higher number of concurrent requests.
- It has faster static content delivery with low resource usage.

I won't go further into the whole Apache vs NGINX debate. But if you wish to learn more about the differences between them in detail, this excellent article from Justin Ellingwood may help.

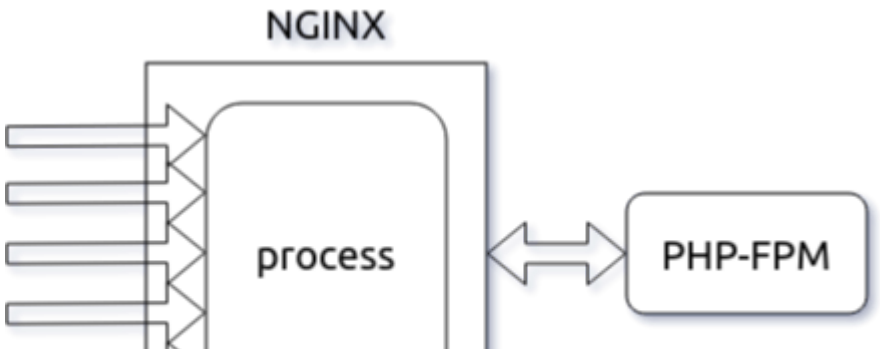
In fact, to explain NGINX's request handling technique, I would like to quote two paragraphs from Justin's article here:

> Nginx came onto the scene after Apache, with more awareness of the concurrency problems that would face sites at scale. Leveraging this knowledge, Nginx was designed from the ground up to use an asynchronous, non-blocking, event-driven connection handling algorithm.
>
> Nginx spawns worker processes, each of which can handle thousands of connections. The worker processes accomplish this by implementing a fast looping mechanism that continuously checks for and processes events. Decoupling actual work from connections allows each worker to concern itself with a connection only when a new event has been triggered.




NGINX is faster in static content delivery while staying relatively lighter on resources because it doesn't embed a dynamic programming language processor. When a request for static content comes, NGINX simply responds with the file without running any additional processes.

That doesn't mean that NGINX can't handle requests that require a dynamic programming language processor. In such cases, NGINX simply delegates the tasks to separate processes such as PHP-FPM, Node.js or Python. Then, once that process finishes its work, NGINX reverse proxies the response back to the client.



NGINX is also a lot easier to configure thanks to a configuration file syntax inspired from various scripting languages that results in compact, easily maintainable configuration files.

# How to Install NGINX

Installing NGINX on a Linux-based system is pretty straightforward. You can either us a virtual private server running Ubuntu as your playground, or you can provision a virtual machine on your local system using Vagrant.

For the most part, provisioning a local virtual machine will suffice and that's the way I'll be using in this article.

## How to Provision a Local Virtual Machine

For those who doesn't know, Vagrant is an open-source tool by Hashicorp that allows you to provision virtual machines using simple configuration files.

For this approach to work, you'll need VirtualBox and Vagrant, so go ahead and install them first. If you need a little warm up on the topic, this tutorial may help.

Create a working directory somewhere in your system with a sensible name. Mine is `~/vagrant/nginx-handbook` directory.

Inside the working directory create a file named `Vagrantfile` and put following content in there:

```
  config.vm.hostname = "nginx-handbook-box"

  config.vm.box = "ubuntu/focal64"

  config.vm.define "nginx-handbook-box"

  config.vm.network "private_network", ip: "192.168.20.20"

  config.vm.provider "virtualbox" do |vb|
    vb.cpus = 1
    vb.memory = "1024"
    vb.name = "nginx-handbook"
  end

end
```

This `Vagrantfile` is the configuration file I talked about earlier. It contains information like name of the virtual machine, number of CPUs, size of RAM, the IP address, and more.

To start a virtual machine using this configuration, open your terminal inside the working directory and execute the following command:

```
vagrant up

# Bringing machine 'nginx-handbook-box' up with 'virtualbox' provider...
# ==> nginx-handbook-box: Importing base box 'ubuntu/focal64'...
# ==> nginx-handbook-box: Matching MAC address for NAT networking...
# ==> nginx-handbook-box: Checking if box 'ubuntu/focal64' version '20210415.0.0
# ==> nginx-handbook-box: Setting the name of the VM: nginx-handbook
# ==> nginx-handbook-box: Clearing any previously set network interfaces...
# ==> nginx-handbook-box: Preparing network interfaces based on configuration...
#     nginx-handbook-box: Adapter 1: nat
#     nginx-handbook-box: Adapter 2: hostonly
# ==> nginx-handbook-box: Forwarding ports...
```

```
#     nginx-handbook-box: SSH address: 127.0.0.1:2222
#     nginx-handbook-box: SSH username: vagrant
#     nginx-handbook-box: SSH auth method: private key
#     nginx-handbook-box: Warning: Remote connection disconnect. Retrying...
#     nginx-handbook-box: Warning: Connection reset. Retrying...
#     nginx-handbook-box:
#     nginx-handbook-box: Vagrant insecure key detected. Vagrant will automatica
#     nginx-handbook-box: this with a newly generated keypair for better securit
#     nginx-handbook-box:
#     nginx-handbook-box: Inserting generated public key within guest...
#     nginx-handbook-box: Removing insecure key from the guest if it's present..
#     nginx-handbook-box: Key inserted! Disconnecting and reconnecting using new
# ==> nginx-handbook-box: Machine booted and ready!
# ==> nginx-handbook-box: Checking for guest additions in VM...
# ==> nginx-handbook-box: Setting hostname...
# ==> nginx-handbook-box: Configuring and enabling network interfaces...
# ==> nginx-handbook-box: Mounting shared folders...
#     nginx-handbook-box: /vagrant => /home/fhsinchy/vagrant/nginx-handbook

vagrant status

# Current machine states:

# nginx-handbook-box           running (virtualbox)
```

The output of the `vagrant up` command may differ on your system, but as long as `vagrant status` says the machine is running, you're good to go.

Given that the virtual machine is now running, you should be able to SSH into it. To do so, execute the following command:

```
vagrant ssh nginx-handbook-box

# Welcome to Ubuntu 20.04.2 LTS (GNU/Linux 5.4.0-72-generic x86 64)
```

If everything's done correctly you should be logged into your virtual machine, which will be evident by the `vagrant@nginx-handbook-box` line on your terminal.

This virtual machine will be accessible on **http://192.168.20.20** on your local machine. You can even assign a custom domain like **http://nginx-handbook.test** to the virtual machine by adding an entry to your **hosts** file:

```
# on mac and linux terminal
sudo nano /etc/hosts

# on windows command prompt as administrator
notepad c:\windows\system32\drivers\etc\hosts
```

Now append the following line at the end of the file:

```
nginx-handbook.test     192.168.20.20
```

Now you should be able to access the virtual machine on **http://nginx-handbook.test** URI in your browser.

You can stop or destroy the virtual machine by executing the following commands inside the working directory:

```
# to stop the virtual machine
```

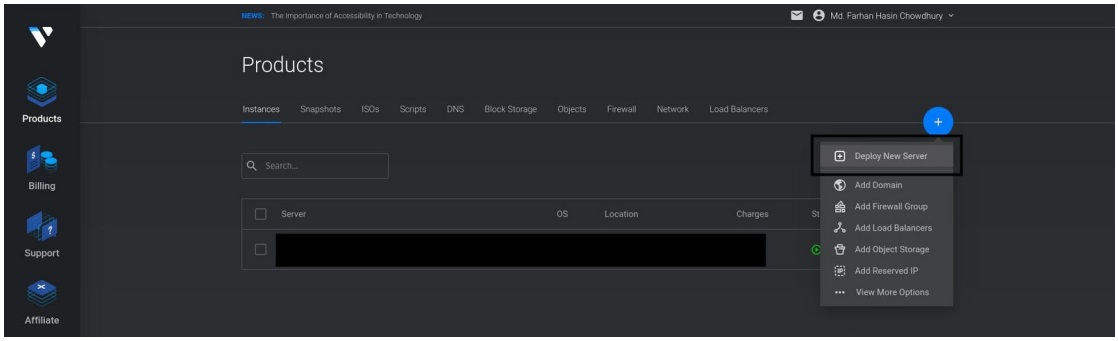
If you want to learn about more Vagrant commands, this cheat sheet may come in handy.

Now that you have a functioning Ubuntu virtual machine on your system, all that is left to do is install NGINX.

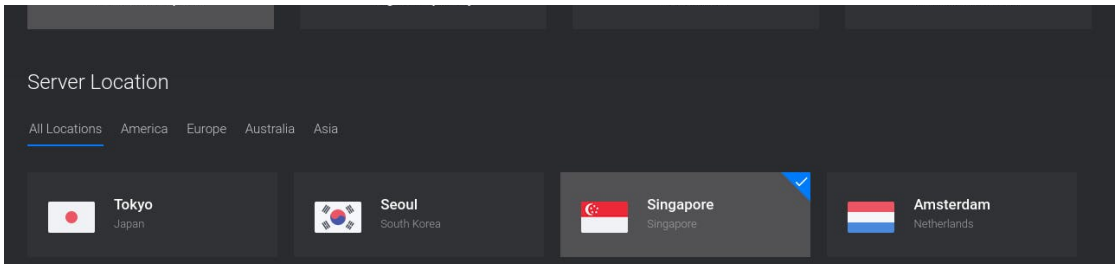
## How to Provision a Virtual Private Server

For this demonstration, I'll use Vultr as my provider but you may use DigitalOcean or whatever provider you like.

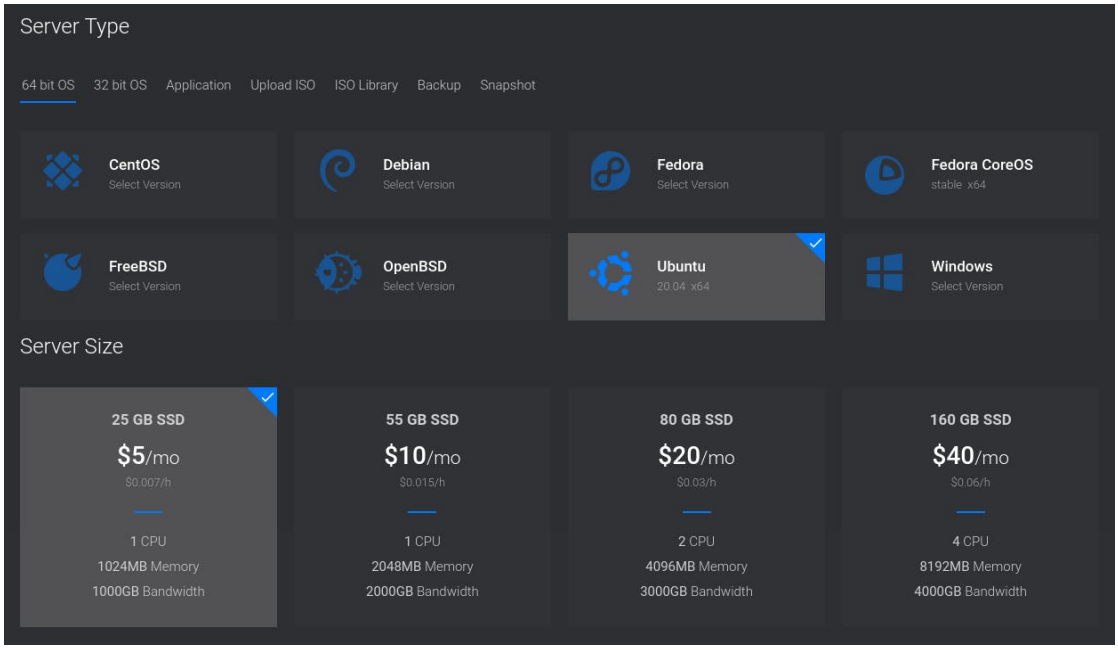
Assuming you already have an account with your provider, log into the account and deploy a new server:




On DigitalOcean, it's usually called a droplet. On the next screen, choose a location close to you. I live in Bangladesh which is why I've chosen Singapore:




On the next step, you'll have to choose the operating system and server size. Choose Ubuntu 20.04 and the smallest possible server size:

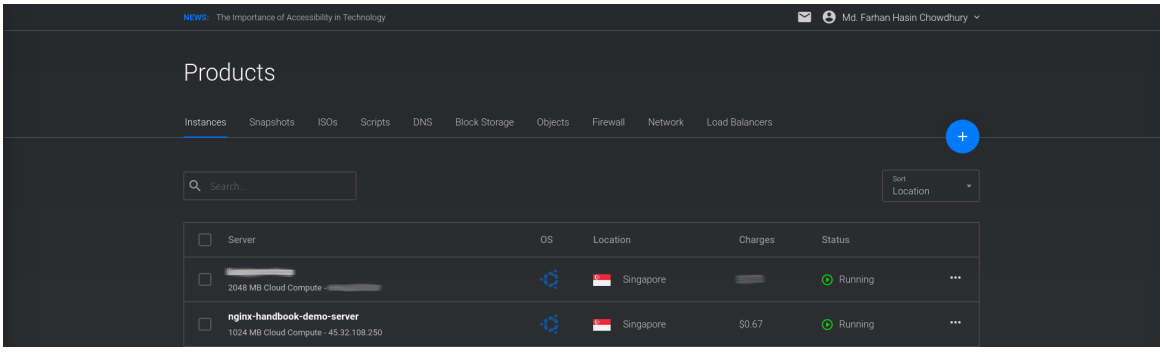



Although production servers tend to be much bigger and more powerful than this, a tiny server will be more than enough for this

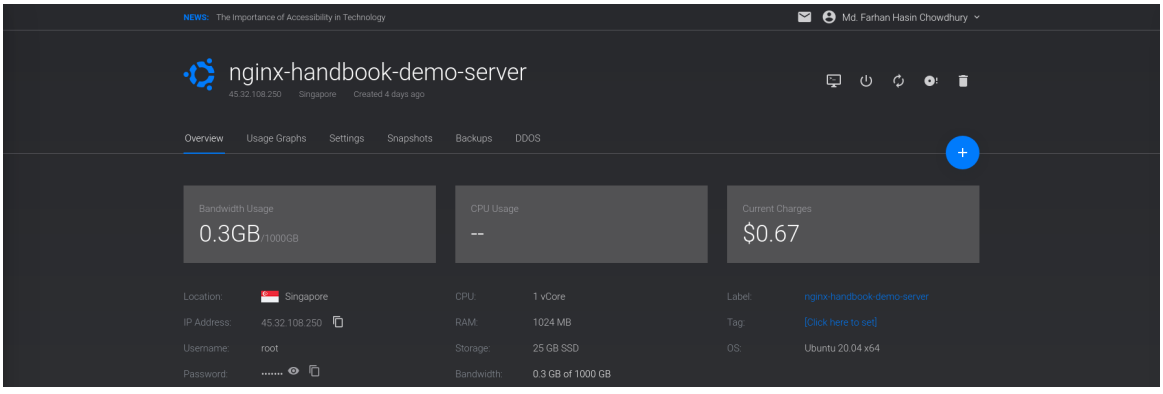
**demo-server** as the server host and label. You can even leave them empty if you want.

Once you're happy with your choices, go ahead and press the **Deploy Now** button.

The deployment process may take some time to finish, but once it's done, you'll see the newly created server on your dashboard:




Also pay attention to the **Status** – it should say **Running** and not **Preparing** or **Stopped**. To connect to the server, you'll need a username and password.



The generic command for logging into a server using SSH is as follows:

```
ssh <username>@<ip address>
```

So in the case of my server, it'll be:

```
ssh root@45.77.251.108

# Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
# Warning: Permanently added '45.77.251.108' (ECDSA) to the list of known hosts.

# root@45.77.251.108's password:
# Welcome to Ubuntu 20.04.2 LTS (GNU/Linux 5.4.0-65-generic x86_64)

# root@localhost:~#
```

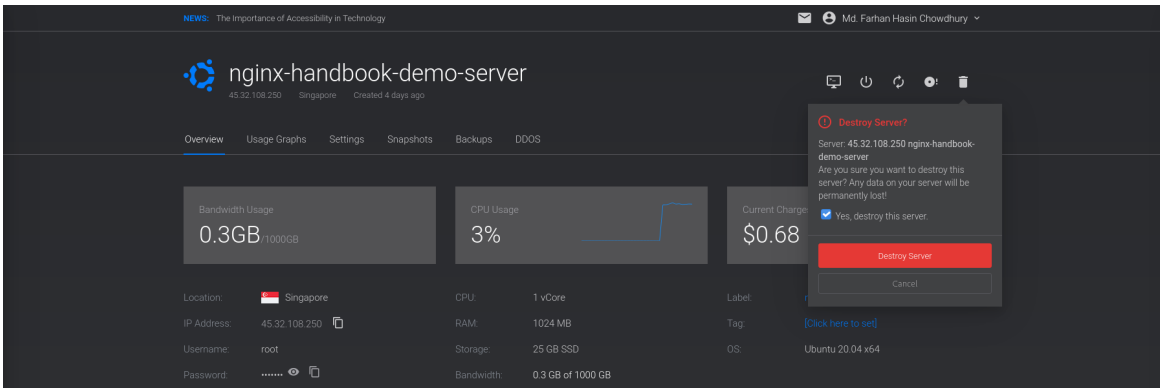
You'll be asked if you want to continue connecting to this server or not. Answer with `yes` and then you'll be asked for the password. Copy the password from the server overview page and paste that into your terminal.

If you do everything correctly you should be logged into your server – you'll see the `root@localhost` line on your terminal. Here `localhost` is the server host name, and may differ in your case.

You can access this server directly by its IP address. Or if you own any custom domain, you can use that also.

operating system's "hosts" file. In case of a real server, you'll have to configure those servers using your DNS provider.

Remember that you'll be charged as long as this server is being used. Although the charge should be very small, I'm warning you anyways. You can destroy the server anytime you want by hitting the trash icon on the server overview page:




If you own a custom domain name, you may assign a sub-domain to this server. Now that you're inside the server, all that is left to is install NGINX.

## How to Install NGINX on a Provisioned Server or Virtual Machine

Assuming you're logged into your server or virtual machine, the first thing you should do is performing an update. Execute the following command to do so:

```
sudo apt update && sudo apt upgrade -y
```

```
sudo apt install nginx -y
```

Once the installation is done, NGINX should be automatically registered as a `systemd` service and should be running. To check, execute the following command:

```
sudo systemctl status nginx

# ● nginx.service - A high performance web server and a reverse proxy server
#      Loaded: loaded (/lib/systemd/system/nginx.service; enabled; vendor preset
#      Active: active (running)
```

If the status says `running`, then you're good to go. Otherwise you may start the service by executing this command:

```
sudo systemctl start nginx
```

Finally for a visual verification that everything is working properly, visit your server/virtual machine with your favorite browser and you should see NGINX's default welcome page:

NGINX is usually installed on the `/etc/nginx` directory and the majority of our work in the upcoming sections will be done in here.

Congratulations! Bow you have NGINX up and running on your server/virtual machine. Now it's time to jump head first into NGINX.

# Introduction to NGINX's Configuration Files

As a web server, NGINX's job is to serve static or dynamic contents to the clients. But how that content are going to be served is usually controlled by configuration files.

NGINX's configuration files end with the `.conf` extension and usually live inside the `/etc/nginx/` directory. Let's begin by `cd` ing into this directory and getting a list of all the files:

```
cd /etc/nginx

ls -lh

# drwxr-xr-x 2 root root 4.0K Apr 21  2020 conf.d
# -rw-r--r-- 1 root root 1.1K Feb  4  2019 fastcgi.conf
# -rw-r--r-- 1 root root 1007 Feb  4  2019 fastcgi_params
# -rw-r--r-- 1 root root 2.8K Feb  4  2019 koi-utf
# -rw-r--r-- 1 root root 2.2K Feb  4  2019 koi-win
# -rw-r--r-- 1 root root 3.9K Feb  4  2019 mime.types
# drwxr-xr-x 2 root root 4.0K Apr 21  2020 modules-available
# drwxr-xr-x 2 root root 4.0K Apr 17 14:42 modules-enabled
# -rw-r--r-- 1 root root 1.5K Feb  4  2019 nginx.conf
# -rw-r--r-- 1 root root  180 Feb  4  2019 proxy_params
# -rw-r--r-- 1 root root  636 Feb  4  2019 scgi_params
# drwxr-xr-x 2 root root 4.0K Apr 17 14:42 sites-available
```

Among these files, there should be one named **nginx.conf**. This is the the main configuration file for NGINX. You can have a look at the content of this file using the `cat` program:

```
cat nginx.conf

# user www-data;
# worker_processes auto;
# pid /run/nginx.pid;
# include /etc/nginx/modules-enabled/*.conf;

# events {
#     worker_connections 768;
#     # multi_accept on;
# }

# http {

#     ##
#     # Basic Settings

#     ##

#     sendfile on;
#     tcp_nopush on;
#     tcp_nodelay on;
#     keepalive_timeout 65;
#     types_hash_max_size 2048;
#     # server_tokens off;

#     # server_names_hash_bucket_size 64;
#     # server_name_in_redirect off;

#     include /etc/nginx/mime.types;
#     default_type application/octet-stream;

#     ##
```

```
#     ssl_prefer_server_ciphers on;

#     ##
#     # Logging Settings
#     ##

#     access_log /var/log/nginx/access.log;
#     error_log /var/log/nginx/error.log;

#     ##
#     # Gzip Settings
#     ##

#     gzip on;

#     # gzip_vary on;
#     # gzip_proxied any;
#     # gzip_comp_level 6;
#     # gzip_buffers 16 8k;
#     # gzip_http_version 1.1;
#     # gzip_types text/plain text/css application/json application/javascript t

#     ##
#     # Virtual Host Configs
#     ##


#     include /etc/nginx/conf.d/*.conf;
#     include /etc/nginx/sites-enabled/*;
# }


# #mail {
# #    # See sample authentication script at:
# #    # http://wiki.nginx.org/ImapAuthenticateWithApachePhpScript
# #
# #    # auth_http localhost/auth.php;
# #    # pop3_capabilities "TOP" "USER";
# #    # imap_capabilities "IMAP4rev1" "UIDPLUS";
# #
# #    server {
# #        listen     localhost:110;
# #        protocol   pop3;
```

```
# #        listen     localhost:143;
# #        protocol   imap;
# #        proxy      on;
# #    }
# #}
```

Whoa! That's a lot of stuff. Trying to understand this file at its current state will be a nightmare. So let's rename the file and create a new empty one:

```
# renames the file
sudo mv nginx.conf nginx.conf.backup

# creates a new file
sudo touch nginx.conf
```

I **highly discourage** you from editing the original `nginx.conf` file unless you absolutely know what you're doing. For learning purposes, you may rename it, but later on, I'll show you how you should go about configuring a server in a real life scenario.

# How to Configure a Basic Web Server

In this section of the book, you'll finally get your hands dirty by configuring a basic static web server from the ground up. The goal of this section is to introduce you to the syntax and fundamental concepts of NGINX configuration files.

text editor:

```
sudo nano /etc/nginx/nginx.conf
```

Throughout the book, I'll be using nano as my text editor. You may use something more modern if you want to, but in a real life scenario, you're most likely to work using nano or vim on servers instead of anything else. So use this book as an opportunity to sharpen your nano skills. Also the official cheat sheet is there for you to consult whenever you need.

After opening the file, update its content to look like this:

```
events {

}

http {

    server {

        listen 80;
        server_name nginx-handbook.test;

        return 200 "Bonjour, mon ami!\n";
    }

}
```

If you have experience building REST APIs then you may guess from

message "Bonjour, mon ami!".

Don't worry if you don't understand anything more than that at the moment. I'll explain this file line by line, but first let's see this configuration in action.

## How to Validate and Reload Configuration Files

After writing a new configuration file or updating an old one, the first thing to do is check the file for any syntax mistakes. The `nginx` binary includes an option `-t` to do just that.

```
sudo nginx -t

# nginx: the configuration file /etc/nginx/nginx.conf syntax is ok
# nginx: configuration file /etc/nginx/nginx.conf test is successful
```

If you have any syntax errors, this command will let you know about them, including the line number.

Although the configuration file is fine, NGINX will not use it. The way NGINX works is it reads the configuration file once and keeps working based on that.

If you update the configuration file, then you'll have to instruct NGINX explicitly to reload the configuration file. There are two ways to do that.

- You can restart the NGINX service by executing the `sudo`

`sudo nginx -s reload` command.

The `-s` option is used for dispatching various signals to NGINX. The available signals are `stop`, `quit`, `reload` and `reopen`. Among the two ways I just mentioned, I prefer the second one simply because it's less typing.

Once you've reloaded the configuration file by executing the `nginx -s reload` command, you can see it in action by sending a simple get request to the server:

```
curl -i http://nginx-handbook.test

# HTTP/1.1 200 OK
# Server: nginx/1.18.0 (Ubuntu)
# Date: Wed, 21 Apr 2021 10:03:33 GMT
# Content-Type: text/plain
# Content-Length: 18
# Connection: keep-alive


# Bonjour, mon ami!
```

The server is responding with a status code of 200 and the expected message. Congratulations on getting this far! Now it's time for some explanation.

## How to Understand Directives and Contexts in NGINX

The few lines of code you've written here, although seemingly simple, introduce two of the most important terminologies of NGINX

Technically, everything inside a NGINX configuration file is a **directive**. Directives are of two types:

- Simple Directives
- Block Directives

A simple directive consists of the directive name and the space delimited parameters, like `listen`, `return` and others. Simple directives are terminated by semicolons.

Block directives are similar to simple directives, except that instead of ending with semicolons, they end with a pair of curly braces `{ }` enclosing additional instructions.

A block directive capable of containing other directives inside it is called a context, that is `events`, `http` and so on. There are four core contexts in NGINX:

- `events { }` – The `events` context is used for setting global configuration regarding how NGINX is going to handle requests on a general level. There can be only one `events` context in a valid configuration file.
- `http { }` – Evident by the name, `http` context is used for defining configuration regarding how the server is going to handle HTTP and HTTPS requests, specifically. There can be only one `http` context in a valid configuration file.
- `server { }` – The `server` context is nested inside the `http` context and used for configuring specific virtual servers within a single host. There can be multiple `server` contexts in a valid

- `main` – The `main` context is the configuration file itself. Anything written outside of the three previously mentioned contexts is on the `main` context.

You can treat contexts in NGINX like scopes in other programming languages. There is also a sense of inheritance among them. You can find an alphabetical index of directives on the official NGINX docs.

I've already mentioned that there can be multiple `server` contexts within a configuration file. But when a request reaches the server, how does NGINX know which one of those contexts should handle the request?

The `listen` directive is one of the ways to identify the correct `server` context within a configuration. Consider the following scenario:

```
http {
    server {
        listen 80;
        server_name nginx-handbook.test;

        return 200 "hello from port 80!\n";
    }


    server {
        listen 8080;
        server_name nginx-handbook.test;

        return 200 "hello from port 8080!\n";
    }
}
```

Now if you send a request to http://nginx-handbook.test:80 then you'll receive "hello from port 80!" as a response. And if you send a request to http://nginx-handbook.test:8080, you'll receive "hello from port 8080!" as a response:

```
curl nginx-handbook.test:80

# hello from port 80!

curl nginx-handbook.test:8080

# hello from port 8080!
```

These two server blocks are like two people holding telephone receivers, waiting to respond when a request reaches one of their numbers. Their numbers are indicated by the `listen` directives.

Apart from the `listen` directive, there is also the `server_name` directive. Consider the following scenario of an imaginary library management application:

```
http {
    server {
        listen 80;
        server_name library.test;

        return 200 "your local library!\n";
    }


    server {
        listen 80;
        server_name librarian.library.test;
```

```
}
```

This is a basic example of the idea of virtual hosts. You're running two separate applications under different server names in the same server.

If you send a request to http://library.test then you'll get "your local library!" as a response. If you send a request to http://librarian.library.test, you'll get "welcome dear librarian!" as a response.

```
curl http://library.test

# your local library!

curl http://librarian.library.test

# welcome dear librarian!
```

To make this demo work on your system, you'll have to update your `hosts` file to include these two domain names as well:

```
192.168.20.20   library.test
192.168.20.20   librarian.library.test
```

Finally, the `return` directive is responsible for returning a valid response to the user. This directive takes two parameters: the status code and the string message to be returned.

## How to Serve Static Content Using NGINX

Now that you have a good understanding of how to write a basic configuration file for NGINX, let's upgrade the configuration to serve static files instead of plain text responses.

In order to serve static content, you first have to store them somewhere on your server. If you list the files and directory on the root of your server using `ls`, you'll find a directory called `/srv` in there:

```
ls -lh /

# lrwxrwxrwx   1 root    root       7 Apr 16 02:10 bin -> usr/bin
# drwxr-xr-x   3 root    root    4.0K Apr 16 02:13 boot
# drwxr-xr-x  16 root    root    3.8K Apr 21 09:23 dev
# drwxr-xr-x  92 root    root    4.0K Apr 21 09:24 etc
# drwxr-xr-x   4 root    root    4.0K Apr 21 08:04 home
# lrwxrwxrwx   1 root    root       7 Apr 16 02:10 lib -> usr/lib
# lrwxrwxrwx   1 root    root       9 Apr 16 02:10 lib32 -> usr/lib32
# lrwxrwxrwx   1 root    root       9 Apr 16 02:10 lib64 -> usr/lib64
# lrwxrwxrwx   1 root    root      10 Apr 16 02:10 libx32 -> usr/libx32

# drwx------   2 root    root     16K Apr 16 02:15 lost+found
# drwxr-xr-x   2 root    root    4.0K Apr 16 02:10 media
# drwxr-xr-x   2 root    root    4.0K Apr 16 02:10 mnt
# drwxr-xr-x   2 root    root    4.0K Apr 16 02:10 opt
# dr-xr-xr-x 152 root    root       0 Apr 21 09:23 proc
# drwx------   5 root    root    4.0K Apr 21 09:59 root
# drwxr-xr-x  26 root    root     820 Apr 21 09:47 run
# lrwxrwxrwx   1 root    root       8 Apr 16 02:10 sbin -> usr/sbin
# drwxr-xr-x   6 root    root    4.0K Apr 16 02:14 snap
# drwxr-xr-x   2 root    root    4.0K Apr 16 02:10 srv
# dr-xr-xr-x  13 root    root       0 Apr 21 09:23 sys
# drwxrwxrwt  11 root    root    4.0K Apr 21 09:24 tmp
# drwxr-xr-x  15 root    root    4.0K Apr 16 02:12 usr
# drwxr-xr-x   1 vagrant vagrant   38 Apr 21 09:23 vagrant
# drwxr-xr-x  14 root    root    4.0K Apr 21 08:34 var
```

served by this system. Now `cd` into this directory and clone the code repository that comes with this book:

```
cd /srv

sudo git clone https://github.com/fhsinchy/nginx-handbook-projects
```

Inside the `nginx-handbook-projects` directory there should a directory called `static-demo` containing four files in total:

```
ls -lh /srv/nginx-handbook-projects/static-demo

# -rw-r--r-- 1 root root 960 Apr 21 11:27 about.html
# -rw-r--r-- 1 root root 960 Apr 21 11:27 index.html
# -rw-r--r-- 1 root root 46K Apr 21 11:27 mini.min.css
# -rw-r--r-- 1 root root 19K Apr 21 11:27 the-nginx-handbook.jpg
```

Now that you have the static content to be served, update your configuration as follows:

```
events {

}

http {

    server {

        listen 80;
```

```
    }

}
```

The code is almost the same, except the `return` directive has now been replaced by a `root` directive. This directive is used for declaring the root directory for a site.

By writing `root /srv/nginx-handbook-projects/static-demo` you're telling NGINX to look for files to serve inside the `/srv/nginx-handbook-projects/static-demo` directory if any request comes to this server. Since NGINX is a web server, it is smart enough to serve the `index.html` file by default.

Let's see if this works or not. Test and reload the updated configuration file and visit the server. You should be greeted with a somewhat broken HTML site:


Although NGINX has served the index.html file correctly, judging by the look of the three navigation links, it seems like the CSS code is not working.

Really, the problem is in the configuration file.

## Static File Type Handling in NGINX

To debug the issue you're facing right now, send a request for the CSS file to the server:

```
curl -I http://nginx-handbook/mini.min.css

# HTTP/1.1 200 OK
# Server: nginx/1.18.0 (Ubuntu)
# Date: Wed, 21 Apr 2021 12:17:16 GMT
# Content-Type: text/plain
# Content-Length: 46887
# Last-Modified: Wed, 21 Apr 2021 11:27:06 GMT
# Connection: keep-alive
# ETag: "60800c0a-b727"
# Accept-Ranges: bytes
```

Pay attention to the **Content-Type** and see how it says **text/plain** and not **text/css**. This means that NGINX is serving this file as plain text instead of as a stylesheet.

Although NGINX is smart enough to find the `index.html` file by default, it's pretty dumb when it comes to interpreting file types. To solve this problem update your configuration once again:

```
events {

}

http {
```

```
    }

    server {

        listen 80;
        server_name nginx-handbook.test;

        root /srv/nginx-handbook-projects/static-demo;
    }
}
```

The only change we've made to the code is a new `types` context nested inside the `http` block. As you may have already guessed from the name, this context is used for configuring file types.

By writing `text/html html` in this context you're telling NGINX to parse any file as `text/html` that ends with the `html` extension.

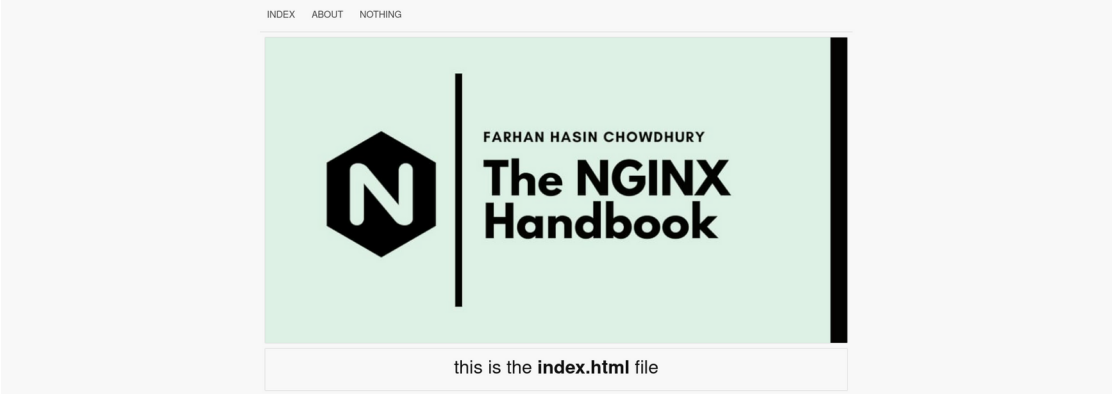
You may think that configuring the CSS file type should suffice as the HTML is being parsed just fine – but no.

If you introduce a `types` context in the configuration, NGINX becomes even dumber and only parses the files configured by you. So if you only define the `text/css css` in this context then NGINX will start parsing the HTML file as plain text.

Validate and reload the newly updated config file and visit the server once again. Send a request for the CSS file once again, and this time the file should be parsed as a **text/css** file:

```
# Date: Wed, 21 Apr 2021 12:29:35 GMT
# Content-Type: text/css
# Content-Length: 46887
# Last-Modified: Wed, 21 Apr 2021 11:27:06 GMT
# Connection: keep-alive
# ETag: "60800c0a-b727"
# Accept-Ranges: bytes
```

Visit the server for a visual verification, and the site should look better this time:




If you've updated and reloaded the configuration file correctly and you're still seeing the old site, perform a hard refresh.

## How to Include Partial Config Files

Mapping file types within the `types` context may work for small projects, but for bigger projects it can be cumbersome and error-prone.

NGINX provides a solution for this problem. If you list the files inside the `/etc/nginx` directory once again, you'll see a file named `mime.ty`

```
ls -lh /etc/nginx

# drwxr-xr-x 2 root root 4.0K Apr 21  2020 conf.d
# -rw-r--r-- 1 root root 1.1K Feb  4  2019 fastcgi.conf
# -rw-r--r-- 1 root root 1007 Feb  4  2019 fastcgi_params
# -rw-r--r-- 1 root root 2.8K Feb  4  2019 koi-utf
# -rw-r--r-- 1 root root 2.2K Feb  4  2019 koi-win
# -rw-r--r-- 1 root root 3.9K Feb  4  2019 mime.types
# drwxr-xr-x 2 root root 4.0K Apr 21  2020 modules-available
# drwxr-xr-x 2 root root 4.0K Apr 17 14:42 modules-enabled
# -rw-r--r-- 1 root root 1.5K Feb  4  2019 nginx.conf
# -rw-r--r-- 1 root root  180 Feb  4  2019 proxy_params
# -rw-r--r-- 1 root root  636 Feb  4  2019 scgi_params
# drwxr-xr-x 2 root root 4.0K Apr 17 14:42 sites-available
# drwxr-xr-x 2 root root 4.0K Apr 17 14:42 sites-enabled
# drwxr-xr-x 2 root root 4.0K Apr 17 14:42 snippets
# -rw-r--r-- 1 root root  664 Feb  4  2019 uwsgi_params
# -rw-r--r-- 1 root root 3.0K Feb  4  2019 win-utf
```

Let's have a look at the content of this file:

```
cat /etc/mime.types

# types {
#     text/html                             html htm shtml;
#     text/css                              css;
#     text/xml                              xml;
#     image/gif                             gif;
#     image/jpeg                            jpeg jpg;
#     application/javascript                js;
#     application/atom+xml                  atom;
#     application/rss+xml                   rss;

#     text/mathml                           mml;
#     text/plain                            txt;
#     text/vnd.sun.j2me.app-descriptor      jad;
#     text/vnd.wap.wml                      wml;
```

```
#    image/vnd.wap.wbmp                 wbmp;
#    image/x-icon                       ico;
#    image/x-jng                        jng;
#    image/x-ms-bmp                     bmp;
#    image/svg+xml                      svg svgz;
#    image/webp                         webp;

#    application/font-woff              woff;
#    application/java-archive           jar war ear;
#    application/json                   json;
#    application/mac-binhex40           hqx;
#    application/msword                 doc;
#    application/pdf                    pdf;
#    application/postscript             ps eps ai;
#    application/rtf                    rtf;
#    application/vnd.apple.mpegurl      m3u8;
#    application/vnd.ms-excel           xls;
#    application/vnd.ms-fontobject      eot;
#    application/vnd.ms-powerpoint      ppt;
#    application/vnd.wap.wmlc           wmlc;
#    application/vnd.google-earth.kml+xml kml;
#    application/vnd.google-earth.kmz   kmz;
#    application/x-7z-compressed        7z;
#    application/x-cocoa                cco;
#    application/x-java-archive-diff    jardiff;
#    application/x-java-jnlp-file       jnlp;

#    application/x-makeself             run;
#    application/x-perl                 pl pm;
#    application/x-pilot                prc pdb;
#    application/x-rar-compressed       rar;
#    application/x-redhat-package-manager rpm;
#    application/x-sea                  sea;
#    application/x-shockwave-flash      swf;
#    application/x-stuffit              sit;
#    application/x-tcl                  tcl tk;
#    application/x-x509-ca-cert         der pem crt;
#    application/x-xpinstall            xpi;
#    application/xhtml+xml              xhtml;
#    application/xspf+xml               xspf;
#    application/zip                    zip;

#    application/octet-stream           bin exe dll;
```

```
#     application/vnd.openxmlformats-officedocument.wordprocessingml.document
#     application/vnd.openxmlformats-officedocument.spreadsheetml.sheet
#     application/vnd.openxmlformats-officedocument.presentationml.presentation

#     audio/midi                            mid midi kar;
#     audio/mpeg                            mp3;
#     audio/ogg                             ogg;
#     audio/x-m4a                           m4a;
#     audio/x-realaudio                     ra;

#     video/3gpp                            3gpp 3gp;
#     video/mp2t                            ts;
#     video/mp4                             mp4;
#     video/mpeg                            mpeg mpg;
#     video/quicktime                       mov;
#     video/webm                            webm;
#     video/x-flv                           flv;
#     video/x-m4v                           m4v;
#     video/x-mng                           mng;
#     video/x-ms-asf                        asx asf;
#     video/x-ms-wmv                        wmv;
#     video/x-msvideo                       avi;
# }
```

The file contains a long list of file types and their extensions. To use this file inside your configuration file, update your configuration to look as follows:

```
events {

}

http {

    include /etc/nginx/mime.types;
```

```
        listen 80;
        server_name nginx-handbook.test;

        root /srv/nginx-handbook-projects/static-demo;
    }

}
```

The old `types` context has now been replaced with a new `include` directive. Like the name suggests, this directive allows you to include content from other configuration files.

Validate and reload the configuration file and send a request for the `mini.min.css` file once again:

```
curl -I http://nginx-handbook.test/mini.min.css

# HTTP/1.1 200 OK
# Server: nginx/1.18.0 (Ubuntu)
# Date: Wed, 21 Apr 2021 12:29:35 GMT
# Content-Type: text/css
# Content-Length: 46887
# Last-Modified: Wed, 21 Apr 2021 11:27:06 GMT
# Connection: keep-alive
# ETag: "60800c0a-b727"
# Accept-Ranges: bytes
```

In the section below on how to understand the main configuration file, I'll demonstrate how `include` can be used to modularize your virtual server configurations.

## Dynamic Routing in NGINX

site root corresponding to the URI the client visits and respond back.

So if the client requests files existing on the root such as `index.html`, `about.html` or `mini.min.css` NGINX will return the file. But if you visit a route such as http://nginx-handbook.test/nothing, it'll respond with the default 404 page:


In this section of the book, you'll learn about the `location` context, variables, redirects, rewrites and the `try_files` directive. There will be no new projects in this section but the concepts you learn here will be necessary in the upcoming sections.

Also the configuration will change very frequently in this section, so do not forget to validate and reload the configuration file after every update.

## Location Matches

The first concept we'll discuss in this section is the `location` context. Update the configuration as follows:

```
events {

}

http {
```

```
        server_name nginx-handbook.test;

        location /agatha {
            return 200 "Miss Marple.\nHercule Poirot.\n";
        }
    }
}
```

We've replaced the `root` directive with a new `location` context. This context is usually nested inside `server` blocks. There can be multiple `location` contexts within a `server` context.

If you send a request to http://nginx-handbook.test/agatha, you'll get a 200 response code and list of characters created by Agatha Christie.

```
curl -i http://nginx-handbook.test/agatha

# HTTP/1.1 200 OK
# Server: nginx/1.18.0 (Ubuntu)
# Date: Wed, 21 Apr 2021 15:59:07 GMT
# Content-Type: text/plain
# Content-Length: 29
# Connection: keep-alive

# Miss Marple.
# Hercule Poirot.
```

Now if you send a request to http://nginx-handbook.test/agatha-christie, you'll get the same response:

```
curl -i http://nginx-handbook.test/agatha-christie
```

```
# Content-Type: text/plain
# Content-Length: 29
# Connection: keep-alive

# Miss Marple.
# Hercule Poirot.
```

This happens because, by writing `location /agatha`, you're telling NGINX to match any URI starting with "agatha". This kind of match is called a **prefix match**.

To perform an **exact match**, you'll have to update the code as follows:

```
events {

}

http {

    server {


        listen 80;
        server_name nginx-handbook.test;

        location = /agatha {
            return 200 "Miss Marple.\nHercule Poirot.\n";
        }
    }

}
```

Adding an `=` sign before the location URI will instruct NGINX to respond only if the URL matches exactly. Now if you send a request to anything but `/agatha`, you'll get a 404 response.

```
curl -I http://nginx-handbook.test/agatha-christie

# HTTP/1.1 404 Not Found
# Server: nginx/1.18.0 (Ubuntu)
# Date: Wed, 21 Apr 2021 16:14:29 GMT
# Content-Type: text/html
# Content-Length: 162
# Connection: keep-alive

curl -I http://nginx-handbook.test/agatha

# HTTP/1.1 200 OK
# Server: nginx/1.18.0 (Ubuntu)
# Date: Wed, 21 Apr 2021 16:15:04 GMT
# Content-Type: text/plain
# Content-Length: 29
# Connection: keep-alive
```

Another kind of match in NGINX is the **regex match**. Using this match you can check location URLs against complex regular expressions.

```
events {

}

http {

    server {

        listen 80;
        server_name nginx-handbook.test;

        location ~ /agatha[0-9] {
            return 200 "Miss Marple.\nHercule Poirot.\n";
        }
    }
```

By replacing the previously used `=` sign with a `~` sign, you're telling NGINX to perform a regular expression match. Setting the location to `~ /agatha[0-9]` means NIGINX will only respond if there is a number after the word "agatha":

```
curl -I http://nginx-handbook.test/agatha

# HTTP/1.1 404 Not Found
# Server: nginx/1.18.0 (Ubuntu)
# Date: Wed, 21 Apr 2021 16:14:29 GMT
# Content-Type: text/html
# Content-Length: 162
# Connection: keep-alive

curl -I http://nginx-handbook.test/agatha8

# HTTP/1.1 200 OK
# Server: nginx/1.18.0 (Ubuntu)
# Date: Wed, 21 Apr 2021 16:15:04 GMT
# Content-Type: text/plain
# Content-Length: 29
# Connection: keep-alive
```

A regex match is by default case sensitive, which means that if you capitalize any of the letters, the location won't work:

```
curl -I http://nginx-handbook.test/Agatha8

# HTTP/1.1 404 Not Found
# Server: nginx/1.18.0 (Ubuntu)
# Date: Wed, 21 Apr 2021 16:14:29 GMT
# Content-Type: text/html
# Content-Length: 162
# Connection: keep-alive
```

To turn this into case insensitive, you'll have to add a `*` after the `~` sign.

```
events {

}

http {

    server {

        listen 80;
        server_name nginx-handbook.test;

        location ~* /agatha[0-9] {
            return 200 "Miss Marple.\nHercule Poirot.\n";
        }
    }

}
```

That will tell NGINX to let go of type sensitivity and match the location anyways.

```
curl -I http://nginx-handbook.test/agatha8

# HTTP/1.1 200 OK
# Server: nginx/1.18.0 (Ubuntu)
# Date: Wed, 21 Apr 2021 16:15:04 GMT
# Content-Type: text/plain
# Content-Length: 29
# Connection: keep-alive

curl -I http://nginx-handbook.test/Agatha8
```

```
# Content-Length: 29
# Connection: keep-alive
```

NGINX assigns priority values to these matches, and a regex match has more priority than a prefix match.

```
events {

}

http {

    server {

        listen 80;
        server_name nginx-handbook.test;

        location /Agatha8 {
            return 200 "prefix matched.\n";
        }

        location ~* /agatha[0-9] {
            return 200 "regex matched.\n";
        }
    }

}
```

Now if you send a request to http://nginx-handbook.test/Agatha8, you'll get the following response:

```
curl -i http://nginx-handbook.test/Agatha8
```

```
# Content-Type: text/plain
# Content-Length: 15
# Connection: keep-alive

# regex matched.
```

But this priority can be changed a little. The final type of match in NGINX is a **preferential prefix match**. To turn a prefix match into a preferential one, you need to include the `^~` modifier before the location URI:

```
events {

}

http {

    server {

        listen 80;

        server_name nginx-handbook.test;

        location ^~ /Agatha8 {
            return 200 "prefix matched.\n";
        }

        location ~* /agatha[0-9] {
            return 200 "regex matched.\n";
        }
    }

}
```

Now if you send a request to http://nginx-handbook.test/Agatha8,

```
curl -i http://nginx-handbook.test/Agatha8

# HTTP/1.1 200 OK
# Server: nginx/1.18.0 (Ubuntu)
# Date: Thu, 22 Apr 2021 08:13:24 GMT
# Content-Type: text/plain
# Content-Length: 16
# Connection: keep-alive

# prefix matched.
```

This time, the prefix match wins. So the list of all the matches in descending order of priority is as follows:

| MATCH | MODIFIER |
| --- | --- |
| Exact | `=` |
| Preferential Prefix | `^~` |
| REGEX | `~` or `~*` |

# Variables in NGINX

Variables in NGINX are similar to variables in other programming languages. The `set` directive can be used to declare new variables anywhere within the configuration file:

```
set $<variable_name> <variable_value>;
```

Variables can be of three types

- String
- Integer
- Boolean

Apart from the variables you declare, there are embedded variables within NGINX modules. An alphabetical index of variables is available in the official documentation.

To see some of the variables in action, update the configuration as follows:

```
events {

}

http {

    server {

        listen 80;
        server_name nginx-handbook.test;

        return 200 "Host - $host\nURI - $uri\nArgs - $args\n";
    }

}
```

Now upon sending a request to the server, you should get a response

```
# curl http://nginx-handbook.test/user?name=Farhan

# Host - nginx-handbook.test
# URI - /user
# Args - name=Farhan
```

As you can see, the `$host` and `$uri` variables hold the root address and the requested URI relative to the root, respectively. The `$args` variable, as you can see, contains all the query strings.

Instead of printing the literal string form of the query strings, you can access the individual values using the `$arg` variable.

```
events {

}

http {

    server {

        listen 80;
        server_name nginx-handbook.test;

        set $name $arg_name; # $arg_<query string name>

        return 200 "Name - $name\n";
    }

}
```

Now the response from the server should look like as follows:

```
# Name - Farhan
```

The variables I demonstrated here are embedded in the ngx_http_core_module. For a variable to be accessible in the configuration, NGINX has to be built with the module embedding the variable. Building NGINX from source and usage of dynamic modules is slightly out of scope for this article. But I'll surely write about that in my blog.

## Redirects and Rewrites

A redirect in NGINX is same as redirects in any other platform. To demonstrate how redirects work, update your configuration to look like this:

```
events {

}

http {

    include /etc/nginx/mime.types;

    server {

        listen 80;
        server_name nginx-handbook.test;

        root /srv/nginx-handbook-projects/static-demo;

        location = /index_page {
                return 307 /index.html;
        }
```

```
    }
}
```

Now if you send a request to http://nginx-handbook.test/about_page, you'll be redirected to http://nginx-handbook.test/about.html:

```
curl -I http://nginx-handbook.test/about_page

# HTTP/1.1 307 Temporary Redirect
# Server: nginx/1.18.0 (Ubuntu)
# Date: Thu, 22 Apr 2021 18:02:04 GMT
# Content-Type: text/html
# Content-Length: 180
# Location: http://nginx-handbook.test/about.html
# Connection: keep-alive
```

As you can see, the server responded with a status code of 307 and the location indicates http://nginx-handbook.test/about.html. If you visit http://nginx-handbook.test/about_page from a browser, you'll see that the URL will automatically change to http://nginx-handbook.test/about.html.

A `rewrite` directive, however, works a little differently. It changes the URI internally, without letting the user know. To see it in action, update your configuration as follows:

```
events {

}
```

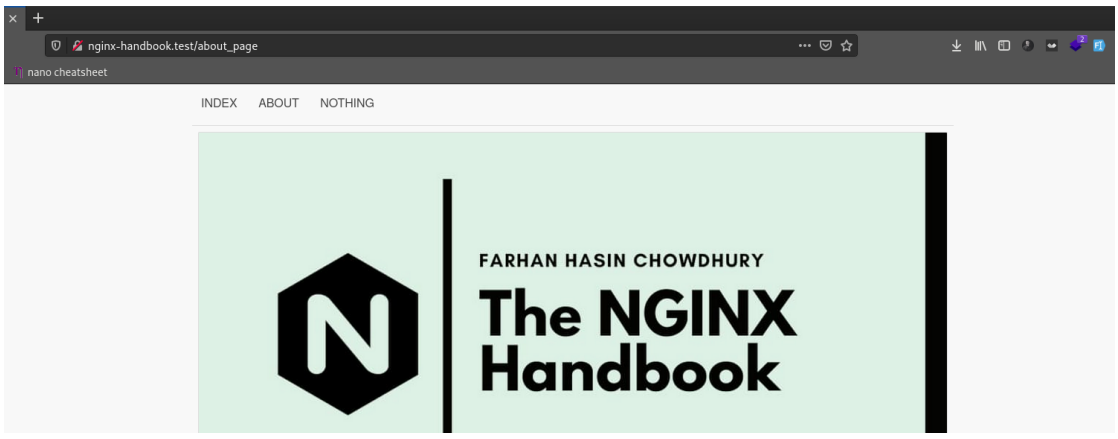
```
    server {

        listen 80;
        server_name nginx-handbook.test;

        root /srv/nginx-handbook-projects/static-demo;

        rewrite /index_page /index.html;

        rewrite /about_page /about.html;
    }
}
```

Now if you send a request to http://nginx-handbook/about_page URI, you'll get a 200 response code and the HTML code for about.html file in response:

```
curl -i http://nginx-handbook.test/about_page

# HTTP/1.1 200 OK
# Server: nginx/1.18.0 (Ubuntu)
# Date: Thu, 22 Apr 2021 18:09:31 GMT
# Content-Type: text/html
# Content-Length: 960
# Last-Modified: Wed, 21 Apr 2021 11:27:06 GMT
# Connection: keep-alive
# ETag: "60800c0a-3c0"
# Accept-Ranges: bytes

# <!DOCTYPE html>
# <html lang="en">
# <head>
#     <meta charset="UTF-8">
#     <meta http-equiv="X-UA-Compatible" content="IE=edge">
#     <meta name="viewport" content="width=device-width, initial-scale=1.0">
#     <title>NGINX Handbook Static Demo</title>
```

```
#             margin-left: auto;
#             margin-right: auto;
#         }
#
#         h1 {
#             text-align: center;
#         }
#     </style>
# </head>
# <body class="container">
#     <header>
#         <a class="button" href="index.html">Index</a>
#         <a class="button" href="about.html">About</a>
#         <a class="button" href="nothing">Nothing</a>
#     </header>
#     <div class="card fluid">
#         <img src="./the-nginx-handbook.jpg" alt="The NGINX Handbook Cover Imag
#     </div>
#     <div class="card fluid">
#         <h1>this is the <strong>about.html</strong> file</h1>
#     </div>
# </body>
# </html>
```

And if you visit the URI using a browser, you'll see the about.html page while the URL remains unchanged:



Apart from the way the URI change is handled, there is another difference between a redirect and rewrite. When a rewrite happens, the `server` context gets re-evaluated by NGINX. So, a rewrite is a more expensive operation than a redirect.

## How to Try for Multiple Files

The final concept I'll be showing in this section is the `try_files` directive. Instead of responding with a single file, the `try_files` directive lets you check for the existence of multiple files.

```
events {

}

http {

    include /etc/nginx/mime.types;

    server {

        listen 80;
        server_name nginx-handbook.test;

        root /srv/nginx-handbook-projects/static-demo;

        try_files /the-nginx-handbook.jpg /not_found;

        location /not_found {
                return 404 "sadly, you've hit a brick wall buddy!\n";
        }
    }
}
```

As you can see, a new `try_files` directive has been added. By writing `try_files /the-nginx-handbook.jpg /not_found;` you're instructing NGINX to look for a file named the-nginx-handbook.jpg on the root whenever a request is received. If it doesn't exist, go to the `/not_found` location.

So now if you visit the server, you'll see the image:


But if you update the configuration to try for a non-existent file such as blackhole.jpg, you'll get a 404 response with the message "sadly, you've hit a brick wall buddy!".

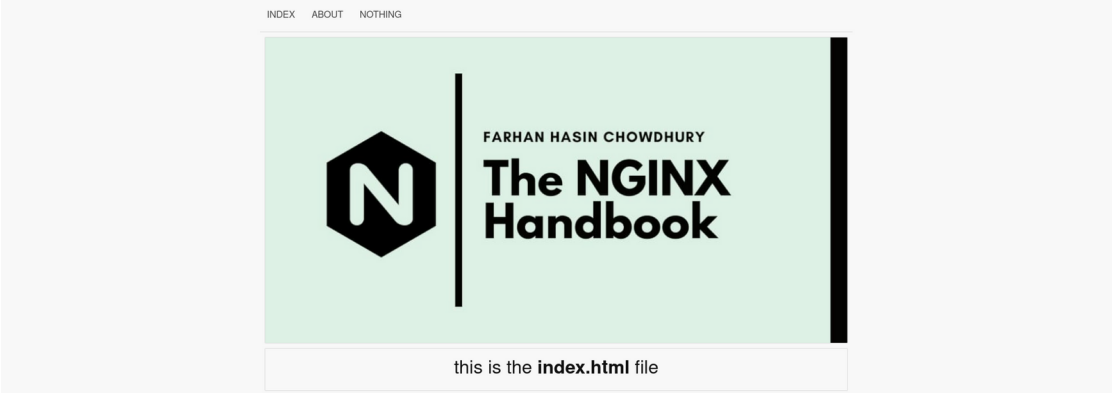
Now the problem with writing a `try_files` directive this way is that no matter what URL you visit, as long as a request is received by the server and the the-nginx-handbook.jpg file is found on the disk, NGINX will send that back.


And that's why `try_files` is often used with the `$uri` NGINX variable.

```
events {

}

http {

    include /etc/nginx/mime.types;

    server {

        listen 80;
        server_name nginx-handbook.test;

        root /srv/nginx-handbook-projects/static-demo;

        try_files $uri /not_found;

        location /not_found {
                return 404 "sadly, you've hit a brick wall buddy!\n";
        }
    }
}
```

try for the URI requested by the client first. If it doesn't find that one, then try the next one.

So now if you visit http://nginx-handbook.test/index.html you should get the old index.html page. The same goes for the about.html page:




But if you request a file that doesn't exist, you'll get the response from the `/not_found` location:

```
curl -i http://nginx-handbook.test/nothing

# HTTP/1.1 404 Not Found
# Server: nginx/1.18.0 (Ubuntu)
# Date: Thu, 22 Apr 2021 20:01:57 GMT
# Content-Type: text/plain
# Content-Length: 38
# Connection: keep-alive

# sadly, you've hit a brick wall buddy!
```

One thing that you may have already noticed is that if you visit the

doesn't correspond to any existing file so NGINX serves you the fallback location. If you want to fix this issue, update your configuration as follows:

```
events {

}

http {

    include /etc/nginx/mime.types;

    server {

        listen 80;
        server_name nginx-handbook.test;

        root /srv/nginx-handbook-projects/static-demo;

        try_files $uri $uri/ /not_found;


        location /not_found {
                return 404 "sadly, you've hit a brick wall buddy!\n";
        }
    }
}
```

By writing `try_files $uri $uri/ /not_found;` you're instructing NGINX to try for the requested URI first. If that doesn't work then try for the requested URI as a directory, and whenever NGINX ends up into a directory it automatically starts looking for an index.html file.

Now if you visit the server, you should get the index.html file just right:


The `try_files` is the kind of directive that can be used in a number of variations. In the upcoming sections, you'll encounter a few other variations but I would suggest that you do some research on the internet regarding the different usage of this directive by yourself.

# Logging in NGINX

By default, NGINX's log files are located inside `/var/log/nginx` . If you list the content of this directory, you may see something as follows:

```
ls -lh /var/log/nginx/

# -rw-r----- 1 www-data adm     0 Apr 25 07:34 access.log
# -rw-r----- 1 www-data adm     0 Apr 25 07:34 error.log
```

Let's begin by emptying the two files.

```
# delete the old files
sudo rm /var/log/nginx/access.log /var/log/nginx/error.log

# create new files
sudo touch /var/log/nginx/access.log /var/log/nginx/error.log
```

If you do not dispatch a `reopen` signal to NGINX, it'll keep writing logs to the previously open streams and the new files will remain empty.

Now to make an entry in the access log, send a request to the server.

```
curl -I http://nginx-handbook.test

# HTTP/1.1 200 OK
# Server: nginx/1.18.0 (Ubuntu)
# Date: Sun, 25 Apr 2021 08:35:59 GMT
# Content-Type: text/html
# Content-Length: 960
# Last-Modified: Sun, 25 Apr 2021 08:35:33 GMT
# Connection: keep-alive
# ETag: "608529d5-3c0"
# Accept-Ranges: bytes

sudo cat /var/log/nginx/access.log

# 192.168.20.20 - - [25/Apr/2021:08:35:59 +0000] "HEAD / HTTP/1.1"
```

As you can see, a new entry has been added to the access.log file. Any request to the server will be logged to this file by default. But we can change this behavior using the `access_log` directive.

```
events {

}

http {
```

```
        listen 80;
        server_name nginx-handbook.test;

        location / {
            return 200 "this will be logged to the default file.\n";
        }

        location = /admin {
            access_log /var/logs/nginx/admin.log;

            return 200 "this will be logged in a separate file.\n";
        }

        location = /no_logging {
            access_log off;

            return 200 "this will not be logged.\n";
        }
    }
}
```

The first `access_log` directive inside the /admin location block instructs NGINX to write any access log of this URI to the `/var/logs/nginx/admin.log` file. The second one inside the /no_logging location turns off access logs for this location completely.

Validate and reload the configuration. Now if you send requests to these locations and inspect the log files, you should see something like this:

```
curl http://nginx-handbook.test/no_logging
# this will not be logged

sudo cat /var/log/nginx/access.log
# empty
```

```
sudo cat /var/log/nginx/access.log
# empty

sudo cat /var/log/nginx/admin.log
# 192.168.20.20 - - [25/Apr/2021:11:13:53 +0000] "GET /admin HTTP/1.1" 200 40 "-

curl  http://nginx-handbook.test/
# this will be logged to the default file.

sudo cat /var/log/nginx/access.log
# 192.168.20.20 - - [25/Apr/2021:11:15:14 +0000] "GET / HTTP/1.1" 200 41 "-" "cu
```

The error.log file, on the other hand, holds the failure logs. To make an entry to the error.log, you'll have to make NGINX crash. To do so, update your configuration as follows:

```
events {

}

http {

    include /etc/nginx/mime.types;

    server {

        listen 80;
        server_name nginx-handbook.test;

        return 200 "..." "...";
    }

}
```

be presented with an error message:

```
sudo nginx -s reload

# nginx: [emerg] invalid number of arguments in "return" directive in /etc/nginx
```

Check the content of the error log and the message should be present there as well:

```
sudo cat /var/log/nginx/error.log

# 2021/04/25 08:35:45 [notice] 4169#4169: signal process started
# 2021/04/25 10:03:18 [emerg] 8434#8434: invalid number of arguments in "return"
```

Error messages have levels. A `notice` entry in the error log is harmless, but an `emerg` or emergency entry has to be addressed right away.

There are eight levels of error messages:

- `debug` – Useful debugging information to help determine where the problem lies.
- `info` – Informational messages that aren't necessary to read but may be good to know.
- `notice` – Something normal happened that is worth noting.
- `warn` – Something unexpected happened, however is not a

- `crit` – There are problems that need to be critically addressed.
- `alert` – Prompt action is required.
- `emerg` – The system is in an unusable state and requires immediate attention.

By default, NGINX records all level of messages. You can override this behavior using the `error_log` directive. If you want to set the minimum level of a message to be `warn`, then update your configuration file as follows:

```
events {

}

http {

    include /etc/nginx/mime.types;

    server {

        listen 80;
        server_name nginx-handbook.test;

        error_log /var/log/error.log warn;

        return 200 "..." "...";
    }

}
```

```
cat /var/log/nginx/error.log

# 2021/04/25 11:27:02 [emerg] 12769#12769: invalid number of arguments in "retur
```

Unlike the previous output, there are no `notice` entries here. `emerg` is a higher level error than `warn` and that's why it has been logged.

For most projects, leaving the error configuration as it is should be fine. The only suggestion I have is to set the minimum error level to `warn`. This way you won't have to look at unnecessary entries in the error log.

But if you want to learn more about customizing logging in NGINX, this link to the official docs may help.

# How to Use NGINX as a Reverse Proxy

When configured as a reverse proxy, NGINX sits between the client and a back end server. The client sends requests to NGINX, then NGINX passes the request to the back end.

Once the back end server finishes processing the request, it sends it back to NGINX. In turn, NGINX returns the response to the client.

During the whole process, the client doesn't have any idea about who's actually processing the request. It sounds complicated in

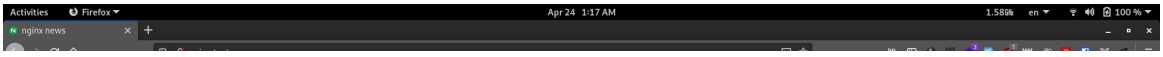
Let's see a very basic and impractical example of a reverse proxy:

```
events {

}

http {

    include /etc/nginx/mime.types;

    server {
        listen 80;
        server_name nginx.test;

        location / {
                proxy_pass "https://nginx.org/";
        }
    }
}
```

Apart from validating and reloading the configuration, you'll also have to add this address to your `hosts` file to make this demo work on your system:

```
192.168.20.20   nginx.test
```

Now if you visit http://nginx.test, you'll be greeted by the original https://nginx.org site while the URI remains unchanged.



stricter handling of upstream server responses, cookie flags handling, cache clearing based on the minimum amount of free space, PROXY protocol support from clients and to backend servers in the mail proxy, proxying SMTP authentication, the set directive in the stream module, and more.

2021-04-13 nginx-1.19.10 mainline version has been released.

2021-03-30 nginx-1.19.9 mainline version has been released.

2021-03-30 njs-0.5.3 version has been released, featuring the js_var directive for http and stream.

2021-03-25 unit-1.23.0 version has been released, featuring SNI support and a number of bugfixes.

2021-03-09 njs-0.5.2 version has been released, featuring js_body_filter directive.

2021-03-09 nginx-1.19.8 mainline version has been released.

2021-02-16 njs-0.5.1 version has been released, featuring Fetch API and js_header_filter directive.

2021-02-16 nginx-1.19.7 mainline version has been released.

2021-02-04 unit-1.22.0 version has been released, featuring a number of bugfixes.

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about
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support

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twitter
blog

unit
njs

You should be even able to navigate around the site to an extent. If you visit http://nginx.test/en/docs/ you should get the http://nginx.org/en/docs/ page in response.

So as you can see, at a basic level, the `proxy_pass` directive simply passes a client's request to a third party server and reverse proxies the response to the client.

## Node.js With NGINX

Now that you know how to configure a basic reverse proxy server, you can serve a Node.js application reverse proxied by NGINX. I've added a demo application inside the repository that comes with this article.

> I'm assuming that you have experience with Node.js and know how to start a Node.js application using PM2.

If you've already cloned the repository inside `/srv/nginx-handbook-projects` then the `node-js-demo` project should be available in the `/srv/nginx-handbook-projects/node-js-demo` directory.

The demo application is a simple HTTP server that responds with a 200 status code and a JSON payload. You can start the application by simply executing `node app.js` but a better way is to use PM2.

For those of you who don't know, PM2 is a daemon process manager widely used in production for Node.js applications. If you want to learn more, this link may help.

Install PM2 globally by executing `sudo npm install -g pm2`. After the installation is complete, execute following command while being inside the `/srv/nginx-handbook-projects/node-js-demo` directory:

```
pm2 start app.js

# [PM2] Process successfully started
# ┌────┬──────────────────┬──────────┬────┬──────────┬──────────┬──────────┐
# | id | name             | mode     | ↺  | status   | cpu      | memory
# ├────┼──────────────────┼──────────┼────┼──────────┼──────────┼──────────┤
# | 0  | app              | fork     | 0  | online   | 0%       | 21.2mb
# └────┴──────────────────┴──────────┴────┴──────────┴──────────┴──────────┘
```

Alternatively you can also do `pm2 start /srv/nginx-handbook-projects/node-js-demo/app.js` from anywhere on the server. You can stop the application by executing the `pm2 stop app` command.

The application should be running now but should not be accessible from outside of the server. To verify if the application is running or not, send a get request to http://localhost:3000 from inside your server:

```
# HTTP/1.1 200 OK
# X-Powered-By: Express
# Content-Type: application/json; charset=utf-8
# Content-Length: 62
# ETag: W/"3e-XRN25R5fWNH2Tc8FhtUcX+RZFFo"
# Date: Sat, 24 Apr 2021 12:09:55 GMT
# Connection: keep-alive
# Keep-Alive: timeout=5

# { "status": "success", "message": "You're reading The NGINX Handbook!" }
```

If you get a 200 response, then the server is running fine. Now to configure NGINX as a reverse proxy, open your configuration file and update its content as follows:

```
events {


}

http {
    listen 80;
    server_name nginx-handbook.test

    location / {
        proxy_pass http://localhost:3000;
    }
}
```

Nothing new to explain here. You're just passing the received request to the Node.js application running at port 3000. Now if you send a request to the server from outside you should get a response as follows:

```
# HTTP/1.1 200 OK
# Server: nginx/1.18.0 (Ubuntu)
# Date: Sat, 24 Apr 2021 14:58:01 GMT
# Content-Type: application/json
# Transfer-Encoding: chunked
# Connection: keep-alive

# { "status": "success", "message": "You're reading The NGINX Handbook!" }
```

Although this works for a basic server like this, you may have to add a few more directives to make it work in a real world scenario depending on your application's requirements.

For example, if your application handles web socket connections, then you should update the configuration as follows:

```
events {

}

http {
    listen 80;
    server_name nginx-handbook.test

    location / {
        proxy_pass http://localhost:3000;
        proxy_http_version 1.1;
        proxy_set_header Upgrade $http_upgrade;
        proxy_set_header Connection 'upgrade';
    }
}
```

The `proxy_http_version` directive sets the HTTP version for the

```
proxy_set_header <header name> <header value>
```

So, by writing `proxy_set_header Upgrade $http_upgrade;` you're instructing NGINX to pass the value of the `$http_upgrade` variable as a header named `Upgrade` – same for the `Connection` header.

If you would like to learn more about web socket proxying, this link to the official NGINX docs may help.

Depending on the headers required by your application, you may have to set more of them. But the above mentioned configuration is very commonly used to serve Node.js applications.

## PHP With NGINX

PHP and NGINX go together like bread and butter. After all the E and the P in the LEMP stack stand for NGINX and PHP.

> I'm assuming you have experience with PHP and know how to run a PHP application.

I've already included a demo PHP application in the repository that comes with this article. If you've already cloned it in the `/srv/nginx-handbook-projects` directory, then the application should be inside `/srv/nginx-handbook-projects/php-demo`.

For this demo to work, you'll have to install a package called PHP-

```
sudo apt install php-fpm -y
```

To test out the application, start a PHP server by executing the following command while inside the `/srv/nginx-handbook-projects/php-demo` directory:

```
php -S localhost:8000

# [Sat Apr 24 16:17:36 2021] PHP 7.4.3 Development Server (http://localhost:8000
```

Alternatively you can also do `php -S localhost:8000 /srv/nginx-handbook-projects/php-demo/index.php` from anywhere on the server.

The application should be running at port 8000 but it can not be accessed from the outside of the server. To verify, send a get request to http://localhost:8000 from inside your server:

```
curl -I localhost:8000

# HTTP/1.1 200 OK
# Host: localhost:8000
# Date: Sat, 24 Apr 2021 16:22:42 GMT
# Connection: close
# X-Powered-By: PHP/7.4.3
# Content-type: application/json

# {"status":"success","message":"You're reading The NGINX Handbook!"}
```

to localhost:8000 – but with PHP, there is a better way.

The FPM part in PHP-FPM stands for FastCGI Process Module. FastCGI is a protocol just like HTTP for exchanging binary data. This protocol is slightly faster than HTTP and provides better security.

To use FastCGI instead of HTTP, update your configuration as follows:

```
events {

}

http {

      include /etc/nginx/mime.types;

      server {

          listen 80;

          server_name nginx-handbook.test;
          root /srv/nginx-handbook-projects/php-demo;

          index index.php;

          location / {
              try_files $uri $uri/ =404;
          }

          location ~ \.php$ {
              fastcgi_pass unix:/var/run/php/php7.4-fpm.sock;
              fastcgi_param REQUEST_METHOD $request_method;
              fastcgi_param SCRIPT_FILENAME $realpath_root$fastcgi_script_name;
      }
   }
}
```

it's called index.php. So by writing `index index.php`, you're instructing NGINX to use the index.php file as root instead.

This directive can accept multiple parameters. If you write something like `index index.php index.html`, NGINX will first look for index.php. If it doesn't find that file, it will look for an index.html file.

The `try_files` directive inside the first `location` context is the same as you've seen in a previous section. The `=404` at the end indicates the error to throw if none of the files are found.

The second `location` block is the place where the main magic happens. As you can see, we've replaced the `proxy_pass` directive by a new `fastcgi_pass`. As the name suggests, it's used to pass a request to a FastCGI service.

The PHP-FPM service by default runs on port 9000 of the host. So instead of using a Unix socket like I've done here, you can pass the request to `http://localhost:9000` directly. But using a Unix socket is more secure.

If you have multiple PHP-FPM versions installed, you can simply list all the socket file locations by executing the following command:

```
sudo find / -name *fpm.sock

# /run/php/php7.4-fpm.sock
# /run/php/php-fpm.sock
# /etc/alternatives/php-fpm.sock
# /var/lib/dpkg/alternatives/php-fpm.sock
```

FPM installed on your system. I prefer using the one with the version number. This way even if PHP-FPM gets updated, I'll be certain about the version I'm using.

Unlike passing requests through HTTP, passing requests through FPM requires us to pass some extra information.

The general way of passing extra information to the FPM service is using the `fastcgi_param` directive. At the very least, you'll have to pass the request method and the script name to the back-end service for the proxying to work.

The `fastcgi_param REQUEST_METHOD $request_method;` passes the request method to the back-end and the `fastcgi_param SCRIPT_FILENAME $realpath_root$fastcgi_script_name;` line passes the exact location of the PHP script to run.

At this state, your configuration should work. To test it out, visit your server and you should be greeted by something like this:


Well, that's weird. A 500 error means NGINX has crashed for some reason. This is where the error logs can come in handy. Let's have a look at the last entry in the error.log file:

```
tail -n 1 /var/log/nginx/error.log
```

Seems like the NGINX process is being denied permission to access the PHP-FPM process.

One of the main reasons for getting a permission denied error is user mismatch. Have a look at the user owning the NGINX worker process.

```
ps aux | grep nginx

# root         677  0.0  0.4   8892  4260 ?        Ss   14:31   0:00 nginx: mast
# nobody     17691  0.0  0.3   9328  3452 ?        S    17:09   0:00 nginx: work
# vagrant    18224  0.0  0.2   8160  2552 pts/0    S+   17:19   0:00 grep --colo
```

As you can see, the process is currently owned by `nobody`. Now inspect the PHP-FPM process.

```
# ps aux | grep php

# root       14354  0.0  1.8 195484 18924 ?        Ss   16:11   0:00 php-fpm: ma
# www-data   14355  0.0  0.6 195872  6612 ?        S    16:11   0:00 php-fpm: po
# www-data   14356  0.0  0.6 195872  6612 ?        S    16:11   0:00 php-fpm: po
# vagrant    18296  0.0  0.0   8160   664 pts/0    S+   17:20   0:00 grep --colo
```

This process, on the other hand, is owned by the `www-data` user. This is why NGINX is being denied access to this process.

To solve this issue, update your configuration as follows:

```
events {

}

http {

      include /etc/nginx/mime.types;

      server {

          listen 80;
          server_name nginx-handbook.test;
          root /srv/nginx-handbook-projects/php-demo;

          index index.php;

          location / {
              try_files $uri $uri/ =404;
          }

          location ~ \.php$ {
              fastcgi_pass unix:/var/run/php/php7.4-fpm.sock;
              fastcgi_param REQUEST_METHOD $request_method;
              fastcgi_param SCRIPT_FILENAME $realpath_root$fastcgi_script_name;
      }
   }
}
```

The `user` directive is responsible for setting the owner for the NGINX worker processes. Now inspect the the NGINX process once again:

```
# ps aux | grep nginx

# root         677  0.0  0.4   8892  4264 ?        Ss   14:31   0:00 nginx: mast
# www-data   20892  0.0  0.3   9292  3504 ?        S    18:10   0:00 nginx: work
# vagrant    21294  0.0  0.2   8160  2568 pts/0    S+   18:18   0:00 grep --colc
```

Undoubtedly the process is now owned by the `www-data` user. Send a request to your server to check if it's working or not:

```
# curl -i http://nginx-handbook.test

# HTTP/1.1 200 OK
# Server: nginx/1.18.0 (Ubuntu)
# Date: Sat, 24 Apr 2021 18:22:24 GMT
# Content-Type: application/json
# Transfer-Encoding: chunked
# Connection: keep-alive

# {"status":"success","message":"You're reading The NGINX Handbook!"}
```

If you get a 200 status code with a JSON payload, you're good to go.

This simple configuration is fine for the demo application, but in real-life projects you'll have to pass some additional parameters.

For this reason, NGINX includes a partial configuration called `fastcgi_params`. This file contains a list of the most common FastCGI parameters.

```
cat /etc/nginx/fastcgi_params

# fastcgi_param  QUERY_STRING       $query_string;
# fastcgi_param  REQUEST_METHOD     $request_method;
# fastcgi_param  CONTENT_TYPE       $content_type;
# fastcgi_param  CONTENT_LENGTH     $content_length;

# fastcgi_param  SCRIPT_NAME        $fastcgi_script_name;
# fastcgi_param  REQUEST_URI        $request_uri;
```

```
# fastcgi_param  HTTPS              $https if_not_empty;

# fastcgi_param  GATEWAY_INTERFACE  CGI/1.1;
# fastcgi_param  SERVER_SOFTWARE    nginx/$nginx_version;

# fastcgi_param  REMOTE_ADDR        $remote_addr;
# fastcgi_param  REMOTE_PORT        $remote_port;
# fastcgi_param  SERVER_ADDR        $server_addr;
# fastcgi_param  SERVER_PORT        $server_port;
# fastcgi_param  SERVER_NAME        $server_name;

# PHP only, required if PHP was built with --enable-force-cgi-redirect
# fastcgi_param  REDIRECT_STATUS    200;
```

As you can see, this file also contains the `REQUEST_METHOD` parameter. Instead of passing that manually, you can just include this file in your configuration:

```
user www-data;

events {

}

http {

      include /etc/nginx/mime.types;

      server {

          listen 80;
          server_name nginx-handbook.test;
          root /srv/nginx-handbook-projects/php-demo;

          index index.php;

          location / {
```

```
        location ~ \.php$ {
            fastcgi_pass unix:/var/run/php/php7.4-fpm.sock;
            fastcgi_param SCRIPT_FILENAME $realpath_root$fastcgi_script_name;
            include /etc/nginx/fastcgi_params;
        }
    }
}
```

Your server should behave just the same. Apart from the `fastcgi_params` file, you may also come across the `fastcgi.conf` file which contains a slightly different set of parameters. I would suggest that you avoid that due to some inconsistencies with its behavior.

# How to Use NGINX as a Load Balancer

Thanks to the reverse proxy design of NGINX, you can easily configure it as a load balancer.

I've already added a demo to the repository that comes with this article. If you've already cloned the repository inside the `/srv/nginx-handbook-projects/` directory then the demo should be in the `/srv/nginx-handbook-projects/load-balancer-demo/` directory.

In a real life scenario, load balancing may be required on large scale projects distributed across multiple servers. But for this simple demo, I've created three very simple Node.js servers responding with a server number and 200 status code.

For this demo to work, you'll need Node.js installed on the server. You

servers provided in this demo.

If you haven't already, install PM2 by executing `sudo npm install -g pm2` . After the installation finishes, execute the following commands to start the three Node.js servers:

```
pm2 start /srv/nginx-handbook-projects/load-balancer-demo/server-1.js

pm2 start /srv/nginx-handbook-projects/load-balancer-demo/server-2.js

pm2 start /srv/nginx-handbook-projects/load-balancer-demo/server-3.js

pm2 list

# ┌────┬──────────────────────┬─────────┬────┬──────────┬──────────┬──────────┐
# | id | name                 | mode    | ↺  | status   | cpu      | memory   |
# ├────┼──────────────────────┼─────────┼────┼──────────┼──────────┼──────────┤
# | 0  | server-1             | fork    | 0  | online   | 0%       | 37.4mb
# | 1  | server-2             | fork    | 0  | online   | 0%       | 37.2mb

# | 2  | server-3             | fork    | 0  | online   | 0%       | 37.1mb
# └────┴──────────────────────┴─────────┴────┴──────────┴──────────┴──────────┘
```

Three Node.js servers should be running on localhost:3001, localhost:3002, localhost:3003 respectively.

Now update your configuration as follows:

```
events {

}

http {
```

```
        server localhost:3003;
    }

    server {

        listen 80;
        server_name nginx-handbook.test;

        location / {
            proxy_pass http://backend_servers;
        }
    }
}
```

The configuration inside the `server` context is the same as you've already seen. The `upstream` context, though, is new. An upstream in NGINX is a collection of servers that can be treated as a single backend.

So the three servers you started using PM2 can be put inside a single upstream and you can let NGINX balance the load between them.

To test out the configuration, you'll have to send a number of requests to the server. You can automate the process using a `while` loop in bash:

```
while sleep 0.5; do curl http://nginx-handbook.test; done

# response from server - 2.
# response from server - 3.
# response from server - 1.
# response from server - 2.
# response from server - 3.
# response from server - 1.
```

# Response from server 2:

You can cancel the loop by hitting `Ctrl + C` on your keyboard. As you can see from the responses from the server, NGINX is load balancing the servers automatically.

Of course, depending on the project scale, load balancing can be a lot more complicated than this. But the goal of this article is to get you started, and I believe you now have a basic understanding of load balancing with NGINX. You can stop the three running server by executing `pm2 stop server-1 server-2 server-3` command (and it's a good idea here).

## How to Optimize NGINX for Maximum Performance

In this section of the article, you'll learn about a number of ways to get the maximum performance from your server.

Some of these methods will be application-specific, which means they'll probably need tweaking considering your application requirements. But some of them will be general optimization techniques.

Just like the previous sections, changes in configuration will be frequesnt in this one, so don't forget to validate and reload your configuration file every time.

### How to Configure Worker Processes and

multiple worker processes capable of handling thousands of requests each.

```
sudo systemctl status nginx

# ● nginx.service - A high performance web server and a reverse proxy server
#      Loaded: loaded (/lib/systemd/system/nginx.service; enabled; vendor preset
#      Active: active (running) since Sun 2021-04-25 08:33:11 UTC; 5h 45min ago
#        Docs: man:nginx(8)
#    Main PID: 3904 (nginx)
#       Tasks: 2 (limit: 1136)
#      Memory: 3.2M
#      CGroup: /system.slice/nginx.service
#              ├─ 3904 nginx: master process /usr/sbin/nginx -g daemon on; maste
#              └─16443 nginx: worker process
```

As you can see, right now there is only one NGINX worker process on the system. This number, however, can be changed by making a small change to the configuration file.

```
worker_processes 2;

events {

}

http {

    server {

        listen 80;
        server_name nginx-handbook.test;

        return 200 "worker_processes and worker_connections configuration!\n";
```

The `worker_process` directive written in the `main` context is responsible for setting the number of worker processes to spawn. Now check the NGINX service once again and you should see two worker processes:

```
sudo systemctl status nginx

# ● nginx.service - A high performance web server and a reverse proxy server
#      Loaded: loaded (/lib/systemd/system/nginx.service; enabled; vendor preset
#      Active: active (running) since Sun 2021-04-25 08:33:11 UTC; 5h 54min ago
#        Docs: man:nginx(8)
#     Process: 22610 ExecReload=/usr/sbin/nginx -g daemon on; master_process on;
#    Main PID: 3904 (nginx)
#       Tasks: 3 (limit: 1136)
#      Memory: 3.7M
#      CGroup: /system.slice/nginx.service
#              ├─ 3904 nginx: master process /usr/sbin/nginx -g daemon on; maste

#              ├─22611 nginx: worker process
#              └─22612 nginx: worker process
```

Setting the number of worker processes is easy, but determining the optimal number of worker processes requires a bit more work.

The worker processes are asynchronous in nature. This means that they will process incoming requests as fast as the hardware can.

Now consider that your server runs on a single core processor. If you set the number of worker processes to 1, that single process will utilize 100% of the CPU capacity. But if you set it to 2, the two processes will be able to utilize 50% of the CPU each. So increasing

A rule of thumb in determining the optimal number of worker processes is **number of worker process = number of CPU cores**.

If you're running on a server with a dual core CPU, the number of worker processes should be set to 2. In a quad core it should be set to 4...and you get the idea.

Determining the number of CPUs on your server is very easy on Linux.

```
nproc

# 1
```

I'm on a single CPU virtual machine, so the `nproc` detects that there's one CPU. Now that you know the number of CPUs, all that is left to do is set the number on the configuration.

That's all well and good, but every time you upscale the server and the CPU number changes, you'll have to update the server configuration manually.

NGINX provides a better way to deal with this issue. You can simply set the number of worker processes to `auto` and NGINX will set the number of processes based on the number of CPUs automatically.

```
worker_processes auto;

events {
```

```
    server {

        listen 80;
        server_name nginx-handbook.test;

        return 200 "worker processes and worker connections configuration!\n";
    }
}
```

Inspect the NGINX process once again:

```
sudo systemctl status nginx

# ● nginx.service - A high performance web server and a reverse proxy server
#      Loaded: loaded (/lib/systemd/system/nginx.service; enabled; vendor preset
#      Active: active (running) since Sun 2021-04-25 08:33:11 UTC; 6h ago
#        Docs: man:nginx(8)
#     Process: 22610 ExecReload=/usr/sbin/nginx -g daemon on; master_process on;

#    Main PID: 3904 (nginx)
#       Tasks: 2 (limit: 1136)
#      Memory: 3.2M
#      CGroup: /system.slice/nginx.service
#              ├─ 3904 nginx: master process /usr/sbin/nginx -g daemon on; maste
#              └─23659 nginx: worker process
```

The number of worker processes is back to one again, because that's what is optimal for this server.

Apart from the worker processes there is also the worker connection, indicating the highest number of connections a single worker process can handle.

operating system is allowed to open per core.

Finding out this number is very easy on Linux:

```
ulimit -n

# 1024
```

Now that you have the number, all that is left is to set it in the configuration:

```
worker_processes auto;

events {
    worker_connections 1024;
}

http {

    server {

        listen 80;
        server_name nginx-handbook.test;

        return 200 "worker processes and worker connections configuration!\n";
    }
}
```

The `worker_connections` directive is responsible for setting the number of worker connections in a configuration. This is also the first

values used by NGINX on a general level. The worker connections configuration is one such example.

## How to Cache Static Content

The second technique for optimizing your server is caching static content. Regardless of the application you're serving, there is always a certain amount of static content being served, such as stylesheets, images, and so on.

Considering that this content is not likely to change very frequently, it's a good idea to cache them for a certain amount of time. NGINX makes this task easy as well.

```
worker_processes auto;

events {
    worker_connections 1024;
}

http {

    include /env/nginx/mime.types;

    server {

        listen 80;
        server_name nginx-handbook.test;

        root /srv/nginx-handbook-demo/static-demo;

        location ~* \.(css|js|jpg)$ {
            access_log off;

            add_header Cache-Control public;
            add_header Pragma public;
```

```
    }
}
```

By writing `location ~* .(css|js|jpg)$` you're instructing NGINX to match requests asking for a file ending with `.css`, `.js` and `.jpg`.

In my applications, I usually store images in the WebP format even if the user submits a different format. This way, configuring the static cache becomes even easier for me.

You can use the `add_header` directive to include a header in the response to the client. Previously you've seen the `proxy_set_header` directive used for setting headers on an ongoing request to the backend server. The `add_header` directive on the other hand only adds a given header to the response.

By setting the `Cache-Control` header to public, you're telling the client that this content can be cached in any way. The `Pragma` header is just an older version of the `Cache-Control` header and does more or less the same thing.

The next header, `Vary`, is responsible for letting the client know that this cached content may vary.

The value of `Accept-Encoding` means that the content may vary depending on the content encoding accepted by the client. This will be clarified further in the next section.

Finally the `expires` directive allows you to set the `Expires` header conveniently. The `expires` directive takes the duration of time this

Now to test out the configuration, sent a request for the the-nginx-handbook.jpg file from the server:

```
curl -I http://nginx-handbook.test/the-nginx-handbook.jpg

# HTTP/1.1 200 OK
# Server: nginx/1.18.0 (Ubuntu)
# Date: Sun, 25 Apr 2021 15:58:22 GMT
# Content-Type: image/jpeg
# Content-Length: 19209
# Last-Modified: Sun, 25 Apr 2021 08:35:33 GMT
# Connection: keep-alive
# ETag: "608529d5-4b09"
# Expires: Tue, 25 May 2021 15:58:22 GMT
# Cache-Control: max-age=2592000
# Cache-Control: public
# Pragma: public
# Vary: Accept-Encoding
# Accept-Ranges: bytes
```

As you can see, the headers have been added to the response and any modern browser should be able to interpret them.

# How to Compress Responses

The final optimization technique that I'm going to show today is a pretty straightforward one: compressing responses to reduce their size.

```
worker_processes auto;
```

```
http {
    include /env/nginx/mime.types;

    gzip on;
    gzip_comp_level 3;

    gzip_types text/css text/javascript;

    server {

        listen 80;
        server_name nginx-handbook.test;

        root /srv/nginx-handbook-demo/static-demo;

        location ~* \.(css|js|jpg)$ {
            access_log off;

            add_header Cache-Control public;
            add_header Pragma public;
            add_header Vary Accept-Encoding;
            expires 1M;

        }
    }
}
```

If you're not already familiar with it, GZIP is a popular file format used by applications for file compression and decompression. NGINX can utilize this format to compress responses using the `gzip` directives.

By writing `gzip on` in the `http` context, you're instructing NGINX to compress responses. The `gzip_comp_level` directive sets the level of compression. You can set it to a very high number, but that doesn't guarantee better compression. Setting a number between 1 - 4 gives you an efficient result. For example, I like setting it to 3.

directive. By writing `gzip_types text/css text/javascript;` you're telling NGINX to compress any file with the mime types of text/css and text/javascript.

Configuring compression in NGINX is not enough. The client has to ask for the compressed response instead of the uncompressed responses. I hope you remember the `add_header Vary Accept-Encoding;` line in the previous section on caching. This header lets the client know that the response may vary based on what the client accepts.

As an example, if you want to request the uncompressed version of the mini.min.css file from the server, you may do something like this:

```
curl -I http://nginx-handbook.test/mini.min.css

# HTTP/1.1 200 OK
# Server: nginx/1.18.0 (Ubuntu)
# Date: Sun, 25 Apr 2021 16:30:32 GMT
# Content-Type: text/css
# Content-Length: 46887
# Last-Modified: Sun, 25 Apr 2021 08:35:33 GMT
# Connection: keep-alive
# ETag: "608529d5-b727"
# Expires: Tue, 25 May 2021 16:30:32 GMT
# Cache-Control: max-age=2592000
# Cache-Control: public
# Pragma: public
# Vary: Accept-Encoding
# Accept-Ranges: bytes
```

As you can see, there's nothing about compression. Now if you want to ask for the compressed version of the file, you'll have to send an additional header.

```
curl -I -H "Accept-Encoding: gzip" http://nginx-handbook.test/mini.min.css

# HTTP/1.1 200 OK
# Server: nginx/1.18.0 (Ubuntu)
# Date: Sun, 25 Apr 2021 16:31:38 GMT
# Content-Type: text/css
# Last-Modified: Sun, 25 Apr 2021 08:35:33 GMT
# Connection: keep-alive
# ETag: W/"608529d5-b727"
# Expires: Tue, 25 May 2021 16:31:38 GMT
# Cache-Control: max-age=2592000
# Cache-Control: public
# Pragma: public
# Vary: Accept-Encoding
# Content-Encoding: gzip
```

As you can see in the response headers, the `Content-Encoding` is now set to `gzip` meaning this is the compressed version of the file.

Now if you want to compare the difference in file size, you can do something like this:

```
cd ~
mkdir compression-test && cd compression-test

curl http://nginx-handbook.test/mini.min.css > uncompressed.css

curl -H "Accept-Encoding: gzip" http://nginx-handbook.test/mini.min.css > compre

ls -lh

# -rw-rw-r-- 1 vagrant vagrant 9.1K Apr 25 16:35 compressed.css
# -rw-rw-r-- 1 vagrant vagrant  46K Apr 25 16:35 uncompressed.css
```

smaller and faster.

# How to Understand the Main Configuration File

I hope you remember the original `nginx.conf` file you renamed in an earlier section. According to the Debian wiki, this file is meant to be changed by the NGINX maintainers and not by server administrators, unless they know exactly what they're doing.

But throughout the entire article, I've taught you to configure your servers in this very file. In this section, however, I'll who you how you should configure your servers without changing the `nginx.conf` file.

To begin with, first delete or rename your modified `nginx.conf` file and bring back the original one:

```
sudo rm /etc/nginx/nginx.conf

sudo mv /etc/nginx/nginx.conf.backup /etc/nginx/nginx.conf

sudo nginx -s reload
```

Now NGINX should go back to its original state. Let's have a look at the content of this file once again by executing the `sudo cat /etc/nginx/nginx.conf` file:

```
events {
    worker_connections 768;
    # multi_accept on;
}

http {

    ##
    # Basic Settings
    ##

    sendfile on;
    tcp_nopush on;
    tcp_nodelay on;
    keepalive_timeout 65;
    types_hash_max_size 2048;
    # server_tokens off;

    # server_names_hash_bucket_size 64;
    # server_name_in_redirect off;

    include /etc/nginx/mime.types;
    default_type application/octet-stream;

    ##
    # SSL Settings
    ##

    ssl_protocols TLSv1 TLSv1.1 TLSv1.2 TLSv1.3; # Dropping SSLv3, ref: POODLE
    ssl_prefer_server_ciphers on;

    ##
    # Logging Settings
    ##

    access_log /var/log/nginx/access.log;
    error_log /var/log/nginx/error.log;

    ##
    # Gzip Settings
    ##
```

```
    # gzip_proxied any;
    # gzip_comp_level 6;
    # gzip_buffers 16 8k;
    # gzip_http_version 1.1;
    # gzip_types text/plain text/css application/json application/javascript tex

    ##
    # Virtual Host Configs
    ##

    include /etc/nginx/conf.d/*.conf;
    include /etc/nginx/sites-enabled/*;
}


#mail {
#   # See sample authentication script at:
#   # http://wiki.nginx.org/ImapAuthenticateWithApachePhpScript
#
#   # auth_http localhost/auth.php;
#   # pop3_capabilities "TOP" "USER";
#   # imap_capabilities "IMAP4rev1" "UIDPLUS";
#
#   server {

#       listen     localhost:110;
#       protocol   pop3;
#       proxy      on;
#   }
#
#   server {
#       listen     localhost:143;
#       protocol   imap;
#       proxy      on;
#   }
#}
```

You should now be able to understand this file without much trouble. On the main context `user www-data;`, the `worker_processes auto;` lines should be easily recognizable to you

process and `include /etc/nginx/modules-enabled/*.conf;` includes any configuration file found on the `/etc/nginx/modules-enabled/` directory.

This directory is meant for NGINX dynamic modules. I haven't covered dynamic modules in this article so I'll skip that.

Now inside the the `http` context, under basic settings you can see some common optimization techniques applied. Here's what these techniques do:

- `sendfile on;` disables buffering for static files.
- `tcp_nopush on;` allows sending response header in one packet.
- `tcp_nodelay on;` disables Nagle's Algorithm resulting in faster static file delivery.

The `keepalive_timeout` directive indicates how long to keep a connection open and the `types_hash_maxsize` directive sets the size of the types hash map. It also includes the `mime.types` file by default.

I'll skip the SSL settings simply because we haven't covered them in this article. We've already discussed the logging and gzip settings. You may see some of the directives regarding gzip as commented. As long as you understand what you're doing, you may customize these settings.

You use the `mail` context to configure NGINX as a mail server. We've only talked about NGINX as a web server so far, so I'll skip this as well.

```
##
# Virtual Host Configs
##

include /etc/nginx/conf.d/*.conf;
include /etc/nginx/sites-enabled/*;
```

These two lines instruct NGINX to include any configuration files found inside the `/etc/nginx/conf.d/` and `/etc/nginx/sites-enabled/` directories.

After seeing these two lines, people often take these two directories as the ideal place to put their configuration files, but that's not right.

There is another directory `/etc/nginx/sites-available/` that's

meant to store configuration files for your virtual hosts. The `/etc/nginx/sites-enabled/` directory is meant for storing the symbolic links to the files from the `/etc/nginx/sites-available/` directory.
In fact there is an example configuration:

```
ln -lh /etc/nginx/sites-enabled/

# lrwxrwxrwx 1 root root 34 Apr 25 08:33 default -> /etc/nginx/sites-available/d
```

As you can see, the directory contains a symbolic link to the `/etc/nginx/sites-available/default` file.

linking them to the `/etc/nginx/sites-enabled/` directory.

To demonstrate this concept, let's configure a simple static server. First, delete the default virtual host symbolic link, deactivating this configuration in the process:

```
sudo rm /etc/nginx/sites-enabled/default

ls -lh /etc/nginx/sites-enabled/

# lrwxrwxrwx 1 root root 41 Apr 25 18:01 nginx-handbook -> /etc/nginx/sites-avai
```

Create a new file by executing `sudo touch /etc/nginx/sites-availab le/nginx-handbook` and put the following content in there:

```
server {
    listen 80;
    server_name nginx-handbook.test;

    root /srv/nginx-handbook-projects/static-demo;
}
```

Files inside the `/etc/nginx/sites-available/` directory are meant to be included within the main `http` context so they should contain `ser ver` blocks only.

Now create a symbolic link to this file inside the `/etc/nginx/sites-en abled/` directory by executing the following command:

```
sudo ln -s /etc/nginx/sites-available/nginx-handbook /etc/nginx/sites-enabled/ng

ls -lh /etc/nginx/sites-enabled/

# lrwxrwxrwx 1 root root 34 Apr 25 08:33 default -> /etc/nginx/sites-available/d
# lrwxrwxrwx 1 root root 41 Apr 25 18:01 nginx-handbook -> /etc/nginx/sites-avai
```

Before validating and reloading the configuration file, you'll have to reopen the log files. Otherwise you may get a permission denied error. This happens because the process ID is different this time as a result of swapping the old `nginx.conf` file.

```
sudo rm /var/log/nginx/*.log

sudo touch /var/log/nginx/access.log /var/log/nginx/error.log

sudo nginx -s reopen
```

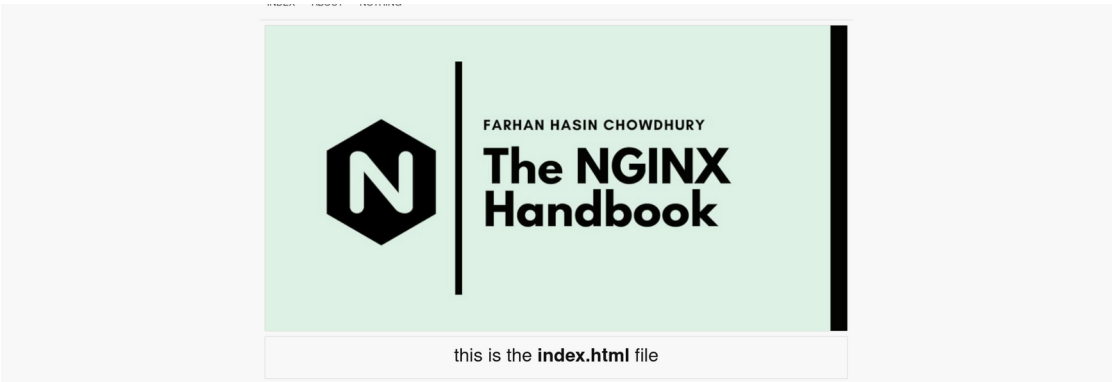
Finally, validate and reload the configuration file:

```
sudo nginx -t

# nginx: the configuration file /etc/nginx/nginx.conf syntax is ok
# nginx: configuration file /etc/nginx/nginx.conf test is successfu

sudo nginx -s reload
```

Visit the server and you should be greeted with the good old The NGINX Handbook page:




If you've configured the server correctly and you're still getting the old NGINX welcome page, perform a hard refresh. The browser often holds on to old assets and requires a little cleanup.

# A Series on Advanced NGINX Concepts

Server configuration is a vast topic, and the goal of this article was to educate you on the fundamentals of NGINX. However there are some important and advanced topics that I've left out.
This is because I plan to write a number of articles on my blog explaining topics like configuring HTTP2 protocol, FastCGI micro caching, rate limiting, SSL certificate signing, dynamic modules, and more.

This way, the series will become a collection of articles that are easy to reference and that are targeted at people with a proper understanding of the basics.

So keep an eye on https://farhan.info/. I'm hoping to get the first

## Show Your Support

Apart from this handbook, I've written handbooks on complex topics such as Containerization with Docker and Server Orcheastration with Kubernetes that are available for free on freeCodeCamp News as well.

These handbooks are part of my mission to simplify hard to understand technologies for everyone. Each of these handbooks takes a lot of time and effort to write.

If you've enjoyed my writing and want to keep me motivated, consider leaving starts on GitHub and endorse me for relevant skills on LinkedIn.

I'm also open to suggestions and discussions. Follow me on Twitter and hit me up with direct messages or emails.

In the end, consider sharing the resources with others, because

> Sharing knowledge is the most fundamental act of friendship. Because it is a way you can give something without loosing something. — Richard Stallman

# Conclusion

I would like to thank you from the bottom of my heart for the time you've spent on reading this article. I hope you've enjoyed your time and have learned all the essentials of NGINX.

If you like my writings, you can find my other books on